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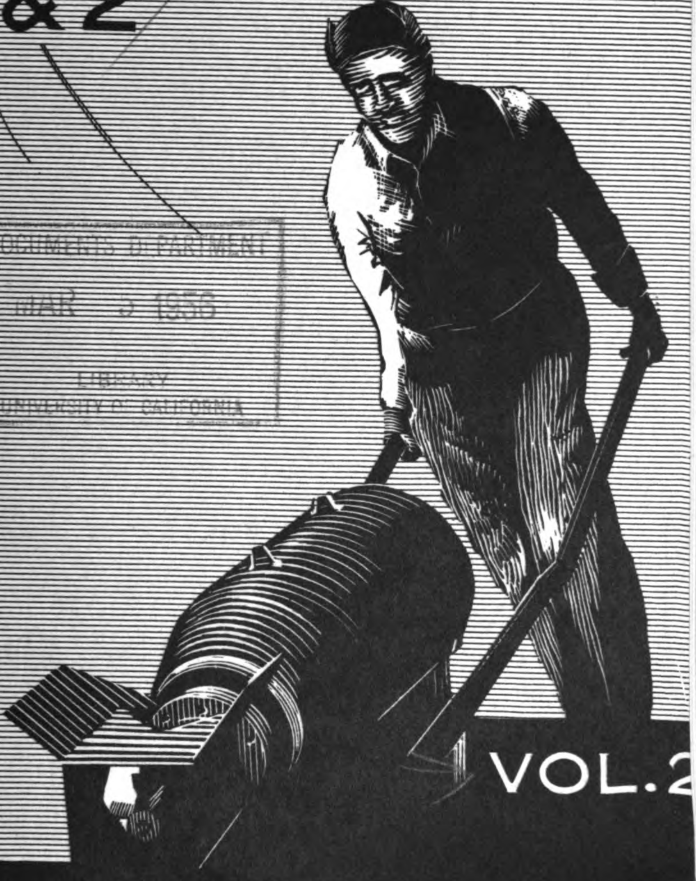

VOL. 2

AVY TRAINING COURS

AVIATION ORDNANCEMAN 3 & 2

Volume 2

Prepared by

U.S. BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

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PREFACE

This Navy Training Course is the second in a series written especially for the Aviation Ordnanceman. Its contents are based on the qualifications for the rates of Aviation Ordnanceman, Third Class, and Aviation Ordnanceman, Second Class. These qualifications are found in the *Manual of Qualifications for Advancement in Rating*, NavPers 18068 (Revised), and are reproduced for the sake of convenience in this course in appendix II.

A proportional share of the Navy's responsibility prosecuting the defense of our nation must go the Aviation Ordnanceman whose job it is to know and understand all aviation ordnance and armament, and to be able to rearm, maintain, repair, and operate this equipment in the most expeditious manner. Only through extensive training and experience will the Aviation Ordnanceman be able to meet this challenge. This course offers another step in the all-important training ladder.

The early chapters of this course cover small arms, 20-mm aircraft guns, electric and electrohydraulic aircraft turrets, and illuminated and computing gunsights. The latter chapters take up bombsights, tow targets, suspension and releasing equipment, and gun cameras.

Aviation Ordnanceman 3 & 2, Volume 2 has been prepared jointly by the U. S. Navy Training Publications Center, Memphis, Tennessee, and the Training Division of the Bureau of Naval Personnel. Credit also is given to the Aviation Ordnanceman School, Jacksonville, Florida, for preparation of the end-of-chapter questions which review the contents of each chapter of this course.

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*"Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services, and materials if the orders calling for them to active duty specify a period of 120 days or more, regardless of the time specified in the active duty orders."

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STUDY GUIDE

Both the striker and the rated Aviation Ordnanceman will be required to read all chapters of this NAVY TRAINING COURSE. This course covers the qualifications for the AO general service rates, and the emergency service rates for AOU and AOT.

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AVIATION ORDNANCEMAN 3 & 2

Volume 2

CHAPTER 1

SMALL ARMS

Strictly defined, the term "small arm" means any firearm of caliber .60 or smaller. However, the term is generally considered to mean a weapon intended to be fired from the hand or shoulder, such as rifles and pistols.

In some duty stations the Aviation Ordnanceman may never have the occasion to use or handle small arms, but at many others he is likely to find himself maintaining, repairing, carrying, and instructing others in the use of all types of small arms. In wartime and certain peacetime situations, for instance, the ordnanceman as a patrol plane aircrewman will usually have one or more submachine guns or carbines to maintain and use as part of his plane's ordnance equipment. These weapons are for survival and crew defense should the plane be forced to ditch or land in enemy territory. At advanced wartime bases the ordnanceman may have to use small arms in defense against surprise attack or infiltration; many of the larger captured islands in the Pacific during World War II harbored large numbers of the enemy who, in desperation and hunger, occasionally raided American installations. At most naval air stations the pistols, carbines, or other weapons carried by security watches are maintained by Aviation Ordnancemen who also instruct other personnel in the proper use and handling of small arms.

The various types of weapons classed as small arms are listed below:

Pistols and revolvers
Rifles
Carbines
Submachine guns
Automatic rifles
Shotguns

Small arms function according to one of four methods of operation: (1) manual, (2) recoil, (3) gas, and (4) blowback.

A good example of a MANUALLY-OPERATED weapon is the old U. S. Rifle, Cal. .30, M1903, commonly though inaccurately called the Springfield rifle. In this rifle, as in civilian bolt-action hunting rifles, the actuation of the bolt BY HAND performs all operations of unlocking the breech, ejecting the empty cartridge case, cocking the weapon, loading a new round into the chamber, and closing and locking the breech. In recoil, gas, or blowback-operated firearms, part of the energy produced by the propellant charge is employed to perform some or all of these functions.

The BOLT, or breechblock, of a weapon is the main working part of the mechanism and is used not only to close the breech but to extract empty cases and feed new rounds into the chamber. When the bolt is fully closed, locked, and ready to fire, it is said to be IN BATTERY.

A RECOIL-OPERATED weapon is one in which the barrel and bolt (or breechblock) are locked together at the moment of firing and move rearward together during recoil. After a short distance, the barrel is stopped and the bolt, being unlocked, continues to recoil against spring pressure until it has moved a sufficient distance to the rear to permit the empty case to be ejected. The force of recoil also cocks the gun and compresses a spring which returns the bolt to its firing position, loading a new round into the chamber in the process. The Automatic Pistol Caliber .45 is an example of a recoil-operated weapon.

A GAS-OPERATED weapon utilizes the force of a small amount of the expanding gas from the propellant to perform the unlocking, extracting, cocking, and reloading operations. The gas generally escapes through a small port in the barrel into a gas cylinder where it moves a piston attached to the breech mechanism. The Browning Automatic Rifle, Cal. .30; Rifle, Cal. .30, M1; and Carbine, Cal. .30 are all examples of gas-operated weapons.

A BLOWBACK-OPERATED weapon is similar in principle of operation to a recoil-operated type, but there are important differences. In a blowback-type mechanism, the breechblock and barrel are not locked together and the barrel itself is nonrecoiling. The bolt or breechblock is held in battery only by the weight of the block and the pressure of a spring.

Further, in a RECOIL-OPERATED gun, the breechblock is never unlocked from the barrel until the bullet is clear of the muzzle and pressure in the barrel is released; a blowback-operated weapon depends for its action on the cartridge case and breechblock moving slightly to the rear under gas pressure while the bullet is still in the barrel. It can be readily seen that the weight of the breechblock is an important factor in the design of a blowback-operated gun; while this type of operation is highly suitable for relatively low-powered cartridges, a military rifle using the standard .30 caliber rifle cartridge in a blowback action would require a breechblock weighing approximately 27 pounds. It is thus apparent that a high-power weapon cannot be operated with a straight inertia or blowback type action.

The Submachine Guns M1928A1 and modifications and M3 and modifications, practically all of the so-called "pocket automatic" pistols of .25, .32, and .380 caliber, most .22 caliber "automatic" pistols, and .22 caliber "automatic" rifles use blowback operation.

The term AUTOMATIC is applied rather indiscriminately to many firearms which are in fact semiautomatic or self-loading. The truly automatic weapon is one which will fire as long as the trigger is pressed. On the other hand, the trigger of the SEMIAUTOMATIC OR SELF-LOADING weapon must be pressed FOR EACH SHOT and then released before the next shot can be fired. The Browning Automatic Rifle, Cal. .30, M1918A2, is a true automatic weapon and will fire at one of two possible rates of fire as long as ammunition remains in the magazine and the trigger is depressed. The Submachine Guns, Cal. .45, M1928A1 and M1, and Carbines, Cal. .30, M2 and M3, may be fired either full-automatic or semiautomatic at the gunner's desire, and are also considered true automatic weapons.

"Automatic pistols" and automatic shotguns" are actually semiautomatic, or self-loading firearms, since the trigger must be pressed for each shot. The service .45 caliber pistol is officially designated "Automatic Pistol, Cal. .45, M1911A1" but it is, nevertheless, semiautomatic in operation.

Following are brief explanations of some of the terms used in this chapter as well as the two chapters following:

BARREL.—The metal tube of a gun through which the projectile travels.

Bore.—The hole running the length of the barrel.

Rifling.—The barrel is produced by boring a hole longitudinally through a bar of steel. Spiral GROOVES are then cut into the walls of the hole; the resulting raised portions between the grooves are called LANDS. The lands and grooves constitute the rifling and impart a spin to the bullet as it travels through the bore, stabilizing it in flight by means of the gyroscopic effect produced.

Smoothbore.—An unrifled bore, as in shotguns.

Caliber.—The caliber of a rifled firearm is the diameter of the bore, measured from LAND TO LAND. The caliber of American military small arms is usually given in hundredths of an inch, although in some British military weapons and many American sporting arms the caliber is given in thousandths of an inch. For example, the Lee-Enfield .303 (British), .222 Remington, and the .357 Magnum revolver cartridge, to mention a few. Foreign calibers other than British are given in millimeters, as are American arms based on foreign design.

Muzzle.—The extreme forward end of the barrel.

Chamber.—The portion of the bore at the rear or breech end of the barrel which holds the round when the weapon is loaded.

Breech.—The extreme aft end of the barrel, including the chamber.

Extractor.—Except in Browning machine guns, the extractor is a part of the bolt or breechblock which pulls the fired case from the chamber as the bolt is moved to the rear.

Ejector.—That part which removes the empty case from the bolt or breechblock after it has been extracted from the chamber. It may be part of either the bolt or the receiver, and usually flips the case clear of the weapon to the side or downward.

Receiver.—The receiver is generally that portion of a gun which is assembled to the barrel and houses the bulk of the operating mechanism, including the bolt or breechblock.

Action.—The "action" of a weapon is a term used to cover all the working parts, regardless of method of operation.

Sear.—The part which generally holds the gun in a cocked position ready to fire. The sear is connected to the trigger and engages either the hammer, firing pin, or the whole bolt, depending on the weapon.

Hammer.—A hinged piece, driven by spring pressure after release by the sear to directly or indirectly strike the primer of the round. In most weapons which employ a hammer, it strikes a firing pin or striker, which in turn fires the round, although in many revolvers the hammer and firing pin are assembled as a unit.

Firing pin.—In arms not using a hammer, the firing pin is held by the sear when cocked and upon release is driven by the firing pin spring against the primer of the round.

Magazine.—The magazine of a weapon is usually a detachable container in either a **box** or **drum** shape. Most current automatic and semiautomatic small arms use a box-type magazine holding 7 to 30 rounds of ammunition, depending on the gun.

Recoil and counterrecoil.—These terms are applied to the reciprocating movement of the bolt and other parts during operation, regardless of the type of operation used. **Recoil** pertains to the rearward motion out of the battery position. **Counterrecoil** is the forward movement of the bolt and associated parts, toward the battery position.

Because of the many different types of small arms, it is impossible in this chapter to thoroughly cover all the details of each, although general data and a brief explanation of each type will be given. In order to be completely familiar with a specific gun, the ordnanceman will have to study the various Army and Navy publications on the subject as well as acquire practical experience in operation, disassembly, and assembly. In general, the *Army Technical Manuals* (TM's) and *Field Manuals* (FM's) are excellent sources of information.

Compared to the Army, the Navy requires relatively few small arms, hence generally uses the same types as the Army and obtains them from that service. This policy allows interchangeability of material and simplifies supply problems.

PISTOLS AND REVOLVERS

Most people, both civilian and military, use the term "pistol" when speaking of any type of firearm held in and fired from the hand. Although the use of the term "pistol" to mean any handgun has become accepted, through long usage, the Aviation Ordnanceman should be technically accurate and use either "pistol" or "revolver" to indicate which type of hand weapon he is referring to, as follows:

Pistol indicates a semiautomatic or self-loading hand weapon of the type often called "automatic pistols." It also means a single-shot handgun sometimes used in match shooting but infrequently seen in this country.

Revolver indicates a manually-operated hand weapon which contains five to nine rounds of ammunition in a revolving cylinder. As the gun is operated, the cylinder is advanced so that a live round is in line with both firing pin and barrel for the next shot. Service revolvers, as well as most large-caliber commercial models, have six chambers in the cylinder.

Subsequent use of the term "automatic pistol" in this text will refer to pistols which are, in fact, semiautomatic in operation. There are certain foreign pistols which can be fired full-automatic, but the great majority of pistols require that the trigger be pressed for each shot. Some nations use "machine pistols" but these weapons are comparable to those which the United States terms submachine guns and are not true pistols.

Revolvers may be "single action" or "double action" in operation. The old Colt Frontier Model or "Peacemaker" is probably the best known example of a single-action revolver, in which the hammer must be pulled back by the thumb to the cocked position before the weapon can be fired. In double-action revolvers, the hammer is normally forward in the firing position. When the trigger is pressed the hammer is drawn back into the cocked position and released automatically, thus eliminating the time-consuming process of cocking the hammer before firing. Most double-action revolvers can be fired in the single-action manner if desired. Practically all modern revolvers use double-action operation.

Automatic Pistol, Caliber .45, Model 1911A1

This pistol, often called the "Colt .45" or "Colt Automatic," is the standard service pistol and is issued to officers as a defensive sidearm, and on occasion to certain petty officers as well. It is often carried by sentries and other watchstanders.

During the uprising of the Moro tribes in the Philippines during the early part of the 20th century, it was found that the fanatic tribesmen often were not stopped when hit by bullets from the .38 caliber sidearms then in use by American troops. This lack of stopping power was one of the factors which led to the adoption of the .45 caliber automatic pistol as the official U. S. sidearm in 1911.

The pistol was designed and patented by John M. Browning who was probably the world's greatest inventor of automatic weapons. The original Model 1911 differs from the current Model 1911A1 only in minor detail and the two operate exactly alike. The Model 1911A1 is a RECOIL-OPERATED, MAGAZINE-FED, SELF-LOADING HAND WEAPON, with a magazine capacity of seven rounds.

The following are the essential features of the Automatic Pistol, Cal. .45, Model 1911A1:

Caliber of bore	**0.45 inch**
Number of grooves	**6**
Uniform twist in rifling, left-hand	**1 turn in 16 inches**
Length of barrel	**5.03 inches**
Overall length of pistol	**8.6 inches**
Weight of pistol	**2 pounds 7 ounces**
Muzzle velocity	**830 f. p. s.**
Maximum range	**1,600 yards at 30 degrees elevation**
Maximum effective range	**75 yards**

The three principal parts of the pistol are the BARREL, SLIDE, and RECEIVER. There is no separate bolt, a portion of the slide serving as a breechblock. In the firing position, the barrel is locked to the slide by means of the transverse

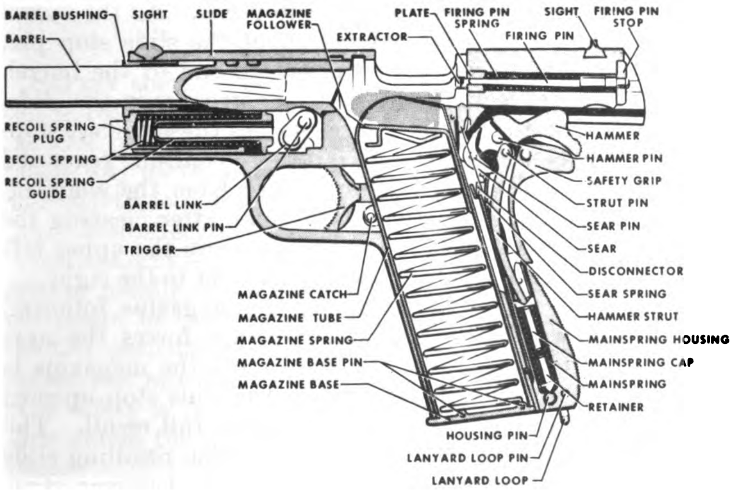


Figure 1–1.—Sectional view of pistol, M1911A1 (full recoil position).

ribs which can be seen on the upper side of the breech end of the barrel in figure 1–1.

Operation.—Assuming a round is in the chamber and the hammer forward, the hammer is pulled back with the thumb to the cocked position against pressure of the mainspring, where it is caught and held by the sear. When the trigger is pressed, the trigger yoke (not shown in fig. 1–1) pushes the disconnector back against the sear, pivoting the upper tip of the sear forward out of the full-cock notch on the hammer. The hammer strut is forced upward by the main spring, rotating the hammer forward to strike the firing pin. The firing pin is the "floating" or inertia type—when the hammer is forward in the firing position the firing pin is still too short to touch the primer of the chambered round, so that if the pistol were carried loaded with hammer down and dropped on the hammer, it would be impossible for the blow to be transmitted to the primer and fire the round. As a safety measure, full hammer travel is required to "bounce" the firing pin into the primer. The firing pin spring then forces the firing pin back into position.

As the round is fired, the bullet is driven forward and recoil starts in the opposite direction. The barrel and slide, being locked together by the locking ribs, recoil together for a distance of about ⅛ inch. The barrel is secured to the receiver by the barrel link and slide stop pin. As the barrel moves rearward, the link rotates about the slide stop pin, with a resultant lowering of the breech end of the barrel. When the barrel locking ribs clear the grooves in the slide, a lug on the bottom of the barrel strikes the receiver, stopping the barrel while the slide is free to continue rearward and the extractor pulls the empty case from the chamber. As it is being pulled farther to the rear after clearing the chamber, the case strikes the fixed ejector on the upper left side of the receiver and is flipped up and out to the right.

As the slide clears the magazine, the magazine follower, pressed upward by the magazine spring, forces the next round up into the path of the slide. (If the magazine is empty, the magazine follower forces the slide stop upward which locks the slide back when it reaches full recoil. The slide stop is not shown in figure 1–1.) The recoiling slide pivots the hammer backward, forcing the hammer strut downward and compressing the mainspring. The bottom of the sear is constantly pressed forward by the long leaf of the 3-leaf sear spring so that the upper tip of the sear is pivoted backward to engage the full-cock notch of the hammer. This locks the hammer back in the cocked position against the pressure of the mainspring.

The recoil spring, which has been compressed as the slide recoils, now forces the slide forward (counterrecoil). The slide hits the next round and as it is guided by the lips of the magazine and the loading ramp on the breech end of the barrel, shoves it forward and into the chamber. As the slide continues forward, it strikes the rear of the barrel, forcing it forward. The barrel link pivots upward around the slide stop pin, raising the rear of the barrel to engage the locking ribs with the grooves in the slide and locking the barrel and slide together. The joint forward movement of the slide and barrel is halted by the lug on the barrel striking the slide stop pin. The pistol is now loaded and cocked, and pressing the trigger will fire the chambered round and repeat the cycle of operation.

It should be noted that the weight of the slide and barrel is so much greater than the weight of the bullet that the latter has been given its maximum velocity and has been driven from the muzzle BEFORE the slide and barrel have recoiled to the point where unlocking occurs.

Safety Devices

SAFETY LOCK.—The safety lock is located on the left side of the receiver, just below and forward of the hammer. In the ON position a projection on the safety lock positively blocks any movement of the sear as well as locking the slide. The safety lock must be in the down or OFF position to fire. The safety lock is not shown in figure 1–1.

GRIP SAFETY.—The grip safety, located on the back of the grip or handle, has a projection which blocks any rearward movement of the trigger yoke. The grip safety is held in the ON position by the right leaf of the 3-leaf sear spring unless the pistol is properly held in the hand, when the grip safety is pivoted inward by the pressure of the hand. This moves the projecting lug upward to clear the trigger yoke.

DISCONNECTOR.—As shown in figure 1–1 when the slide is in battery the lower end of the disconnector provides a connection between the end of the trigger yoke and the sear, and it is normally held in this position by the center leaf of the sear spring. The underside of the slide has a cutout portion to accommodate the upper tip of the disconnector WHEN THE SLIDE IS IN BATTERY; whenever the slide moves from its firing position the tip of the disconnector is cammed down, disconnecting the sear from the trigger yoke (hence the name "disconnector"). Even though disconnected from the trigger, such as during recoil, the sear is free to pivot on its pin and catch the hammer in the full-cock position. It can be seen that once the trigger is pressed and the chambered round fired, the trigger must be released before firing again in order to take pressure off the disconnector and allow the disconnector to move up under spring pressure to provide a link between trigger and sear. Thus, the disconnector prevents automatic fire as well as accidental discharge before the slide is home and locked.

INERTIA FIRING PIN.—The action of the "floating" firing pin has already been described under OPERATION. It too is a safety device.

HALF-COCK NOTCH.—The tip of the sear which engages the hammer is constantly pressed by its spring against the hammer. As the hammer is being cocked by hand, the sear first snaps into the half-cock notch, then continues on to the full-cock notch. Should the hammer slip during manual cocking while the tip of the sear is between the half-cock and full-cock notches, the hammer will fall only as far as the half-cock notch where it will be engaged by the sear. (Should it slip before reaching the half-cock notch, hammer travel will be insufficient to cause the inertia firing pin to fire the round.) It can be seen in figure 1–1 that the shape of the half-cock notch prevents the sear from coming off the notch except when the hammer is pulled farther back. The pistol may be carried with chamber loaded and the hammer on half-cock in complete safety.

It has been mentioned that when the last round is fired the magazine follower forces the slide stop upward to engage a notch in the slide and lock the slide open in the full recoil position; the operator then knows the pistol is empty. To reload, the magazine catch just behind the trigger on the left side of the receiver is pressed. The empty magazine falls out due to a combination of gravity and spring pressure from the magazine spring and a fresh magazine is inserted in the grip. By depressing the slide stop with the thumb, the slide is released, loading a round in the chamber and leaving the pistol ready to commence firing. Magazines should be handled carefully, as damaged or bent magazines cause the great majority of all pistol malfunctions.

The caliber .45 pistol is probably the safest to handle and certainly one of the best designed military pistols in the world. It can take severe use and treatment and still function safely and properly, and in the hands of a trained man is quite accurate. On the other hand, carelessness and ignorance of the weapon have resulted in many accidental injuries and deaths which could have been avoided. Because the .45 caliber pistol is so widely used, the Aviation Ordnanceman should thoroughly know its use and maintenance. It can literally be a lifesaver.

Revolver, Smith and Wesson, Caliber .38 Special

The caliber .38 revolver was issued during World War II as a substitute for the service sidearm, the Automatic Pistol, Cal. .45, M1911A1, and a considerable number are still in

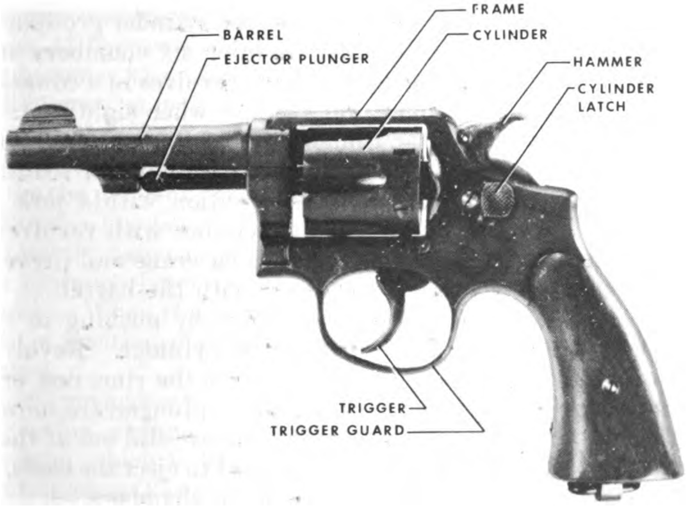


Figure 1–2.—Revolver, Smith and Wesson, Cal. .38 Special.

use. Principally because of its lighter weight it was and is frequently issued to flight personnel instead of the .45 caliber pistol. The revolver is described in *Army Field Manual 23–35* as a "single-shot, breech-loading hand weapon." It is manually operated.

When the revolver was first issued early in World War II, the ammunition supplied for it was the commercial type with unjacketed lead-antimony bullets, and some of this type are still in service. Because the terms agreed upon at the Geneva Convention prohibit the use of expanding bullets in war, this lead-bullet type ammunition MUST NOT BE USED IN COMBAT, although it is suitable for issue within the continental United States and for target and training use. Ammunition containing a jacketed bullet is now standard.

Although designated as a .38 caliber weapon, the revolver, like most so-called .38's, actually has a bore diameter of 0.353 inch. Other essential features are:

Number of grooves (right-hand twist)	5
Length of barrel	4 inches
Overall length of revolver	9¼ inches
Weight of revolver	29 ounces
Muzzle velocity	870 f. p. s.
Maximum range	1,600 yards
Maximum effective range	50 yards

The revolver has two main groups: the cylinder group and the frame group. The cylinder contains six chambers and like other Smith and Wesson revolvers revolves in a counterclockwise direction (looking forward, as when sighting).

Pushing forward on the thumb piece of the cylinder latch permits the cylinder to be swung out to the left for loading and unloading. Performing this operation with a jerk or snap is a sign of ignorance or inexperience with revolvers, since it may cause damage to the cylinder crane and prevent the cylinder from properly aligning with the barrel.

Cartridges or empty cases are ejected by pushing in the ejector plunger toward the rear of the cylinder. Revolver ammunition is usually rimmed, and since the rims rest outside of the ejector, as the ejector and its plunger are moved to the rear, the cartridges or empty cases are slid out of their chambers. If undue pressure is required to eject the cases, it is an indication of dirty, rusty, or worn chambers.

In firing double action, as the trigger is pressed the hammer is drawn back to the cocked position against pressure of the mainspring while at the same time the cylinder is rotated to line up the next chamber with the barrel. At the proper point (still during the cocking action) the cylinder is locked so that it cannot move either way and when the hammer reaches the full-cock position it slips from the trigger and is driven forward by the mainspring. The forward point of the hammer, called the hammer nose, strikes the primer and fires the round. When the trigger is again pressed, the cycle is repeated.

In firing single action, the hammer is drawn back to the full-cock position with the thumb. The trigger engages a small notch in the bottom of the hammer, holding the hammer cocked until released by pressure on the trigger. During the manual cocking action, the cylinder is rotated and locked in firing position. Much greater accuracy is obtained when firing the revolver single action, since the distance the trigger must travel is greatly reduced as is the muscular effort required of the firing hand.

Safety Features

HAMMER BLOCK.—This device prevents the hammer from going far enough forward to strike the primer when both hammer and trigger are in the forward or uncocked position. Thus, if the revolver were dropped or otherwise struck on the hammer, the round would not be fired.

REBOUND SLIDE.—If the hammer should slip from the thumb while being manually cocked, a lug on the rebound slide prevents the hammer from traveling far enough to strike the primer of the round to be fired.

BOLT.—The bolt in this revolver has none of the functions ordinarily associated with the name. The bolt is part of the cylinder latch mechanism and serves also as a safety device. When the cylinder is out of the firing position, the bolt is positioned so as to prevent the hammer from being cocked.

CYLINDER STOP.—As the cylinder rotates during the cocking action, a notch on the cylinder is lined up with the cylinder stop which is located inside the frame just forward of the trigger. The stop is then forced upward to engage the notch and lock the cylinder in the firing position until the trigger again comes to the forward position.

Even though the hammer block provides protection against the gun being accidentally fired by a blow on the hammer, unless immediate use is expected it is advisable to load the cylinder with only five rounds, leaving an empty chamber under the hammer as an additional safety measure.

Training Pistols

Various caliber .22 automatic pistols are used by the Navy for training purposes. The Pistol, Colt Ace, Caliber .22 is unique among these in that it not only closely resembles the service caliber .45 pistol in appearance and operation but produces almost as much recoil force as the .45. This is accomplished by means of a special breech mechanism called a "floating chamber" which in effect magnifies the recoil of the small .22 cartridge. By using the Ace, the shooter becomes proficient in sighting and firing and also becomes accustomed to the heavy recoil of the service pistol, without the more extensive range facilities required for the larger caliber and at considerably less expense. The magazine of this pistol is of 10-round capacity.

Other .22 caliber training pistols used by the Navy are the Colt Match Target Woodsman and several models of Hi-Standard pistols. These guns are of simple blowback operation and are excellent for training in proper sighting and firing, although unlike the Colt Ace, the shooter feels practically no recoil.

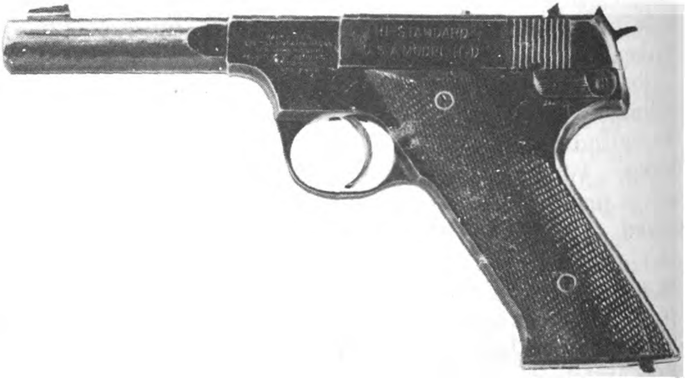


Figure 1—3.—Caliber .22 Hi-Standard Model H—D training pistol.

U. S. CARBINES, CALIBER .30, M1, M1A1, M2, AND M3

The first of this series of carbines (short, light rifles) was the M1 which was developed by Winchester Arms early in World War II and issued to large numbers of men who normally would have been armed with the pistol—officers and noncommissioned officers, machine gun crews, and the like in the Army and Marine Corps, advance base units, construction battalions, and other units of the Navy.

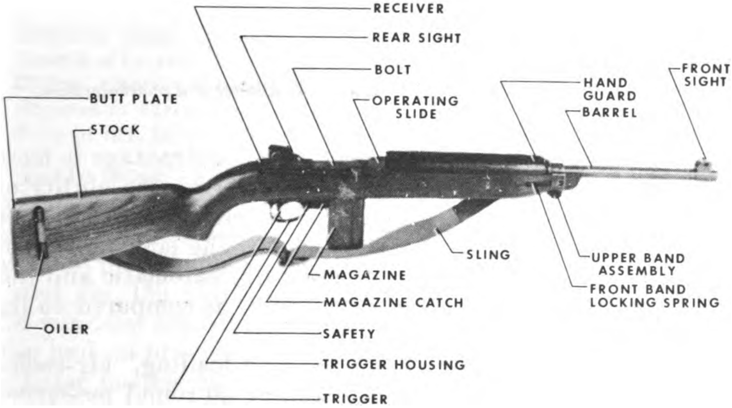


Figure 1–4.—U. S. Carbine, Cal. .30, M1.

The automatic pistol and the revolver, while excellent defense weapons, have an extremely short effective range unless in the hand of an expert. Even then, the maximum range for accuracy is about 75 yards and the average man, in the excitement of combat, does well to hit an enemy at 20 yards range. Further, the pistol or revolver is strictly a personal defense weapon and is not suitable for any kind of organized unit defense against enemy attack.

The various models of carbines have an effective range of 300 yards and are much more useful in the hands of a man who has received normal marksmanship training than is a pistol or revolver. The carbine is light and easy to handle and 100 rounds of ammunition weighs only 2¾ pounds.

One disadvantage of the carbine is that its bullet does not have nearly the "stopping power" of the .45 caliber pistol bullet, which will almost always knock a man down regard-

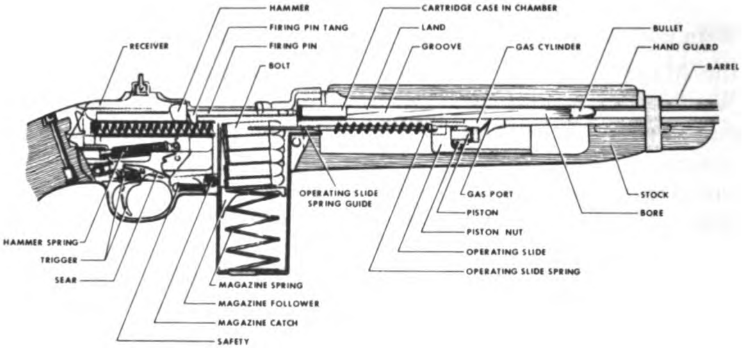


Figure 1–5.—U. S. Carbine, Cal. .30, M1—sectional and phantom view.

less of where he is hit. However, this disadvantage is more than offset (except in very close combat) by the ability of the average man to hit a target with the carbine at far greater range than is possible with the pistol. The later models of carbines (M2 and M3) can be fired fully automatic and this adds greatly to the firepower of a unit, as compared to the pistol.

The carbine is a gas-operated, self-loading, air-cooled shoulder weapon, fed by a 15-round or 30-round magazine. Carbines M1 and M1A1 deliver only semiautomatic fire, while carbines M2 and M3 deliver either semiautomatic or full-automatic fire controlled by the operator through the use of a selector.

The only difference between the carbines M1 and M1A1 is the stock. The M1 has a one-piece wooden stock, while the M1A1 has a folding metal stock extension and a wooden hand grip. All solid stock models are normally equipped with a web sling.

The carbine M2 is the same as the M1 except for differences in design of certain components and the addition of others which permit the M2 to deliver either semiautomatic or full-automatic fire. The M3 is the same as the M2 except that the rear sight is not included and the top of the receiver is designed to accommodate special sighting equipment (sniperscope).

Since the M1 is the model most frequently encountered in the Navy, only it will be discussed in detail. However, the

M2 and M3 are identical in most respects. The following data applies to both the M1 and the M2:

Weight of carbine (with empty 15-round magazine)	5.5 pounds
Weight of carbine (with loaded 15-round magazine)	6.1 pounds
Weight of carbine (with loaded 30-round magazine)	6.6 pounds
Overall length of carbine	35.6 inches
Muzzle velocity	1,970 f. p. s.
Maximum range	2,200 yards at 30 degrees elevation
Effective range	300 yards
Length of barrel	18 inches
Rifling, right-hand, one turn in	20 inches
Grooves in barrel	4
Rate of fire, full automatic (M2)	750–775 r.p.m.

Early models of carbine M1 are equipped with an L-type rear sight, consisting of two arms at right angles, each pierced with an aperture. Either arm may be raised into position by turning with the fingers; the shorter arm is computed for 150 yards range and the longer for 300 yards. No windage adjustment is provided. These earlier models also had no provision for fixing a bayonet to the carbine.

Later models of the M1 have an adjustable sight graduated from 100 to 300 yards in divisions of 50 yards, and may be adjusted to either side to allow for wind. The upper band, which holds the stock to the barrel, incorporates a bayonet stud so that a bayonet may be secured to the carbine if desired. Both types of M1 carbines may be found in use by the Navy.

OPERATION OF THE CARBINE M1.—When the carbine is loaded and the bolt is closed and locked, the hammer is held in the cocked position by the front end of the sear engaging in the sear notch of the hammer. A projection of the trigger (called the trigger lip) is seated under the after end of the sear (fig. 1–6). When the trigger is pressed, it pivots about the trigger pin, causing the rear of the trigger to rise, carrying with it the after end of the sear. This draws the front of the sear down, disengaging it from the hammer which is driven forward by the hammer spring to strike the firing pin in the bolt and fire the chambered round.

When the bullet of the fired round passes the gas port,

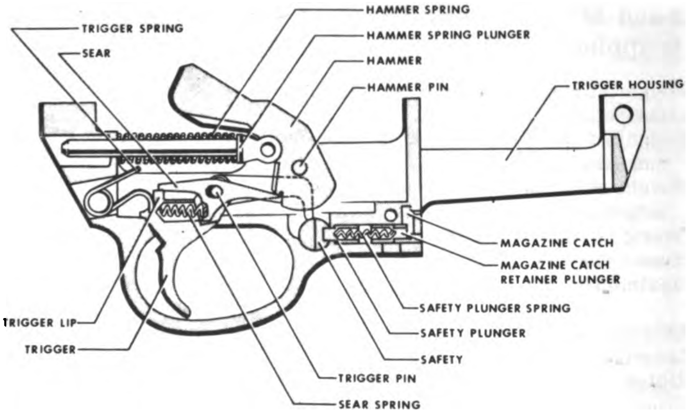


Figure 1–6.—Carbine M1, trigger housing group showing hammer cocked.

some of the gases pass through the port into the gas cylinder (attached to the barrel) where they strike the piston. The piston is driven sharply to the rear for about ¼ inch where it strikes and is stopped by the gas piston nut. Since the forward face of the operating slide is in contact with the piston, the rearward motion of the piston is transmitted to the slide, driving the slide rearward against pressure of the operating slide spring.

The bolt is locked by two lugs located at the front of the bolt, one on either side. An extension of the right lug (the operating lug) engages with a cam recess in the slide, but for the first 5/16 inch of recoil, the slide travels independently of the bolt mechanism, the lug on the bolt merely sliding in a straight section of the recess in the operating slide. This delay permits the bullet to leave the barrel and the high pressure in the barrel to dissipate before the bolt is unlocked by further movement of the slide.

As the slide recoils further, the cam surface of the recess comes in contact with the operating lug and cams it upward, rotating the bolt counterclockwise and disengaging the locking lugs on the bolt from their recesses in the receiver. The firing pin has a downward extension on its after end called the tang, and as the bolt is rotated, the tang is cammed to the rear by a section of the receiver. Thus, the firing pin is withdrawn from the primer and the cocking action of the hammer, which bears against a cam surface on the rear of the bolt, is started at the same time.

As the operating slide continues its movement to the rear, it carries with it the bolt, which slides in the receiver. The empty case is withdrawn from the chamber by the extractor. When the mouth of the case clears the chamber, it is thrown clear of the receiver to the front and right by the spring-loaded ejector which continually presses against the head of the case. As the bolt continues rearward, its after end pivots the hammer down and back against the pressure of the hammer spring. As the bolt comes to the end of its recoil near the rear of the receiver, the magazine is uncovered and the magazine follower and spring force the rounds up so that the top cartridge lies in the path of the bolt. The forward section of the operating slide strikes the front of the receiver and is stopped. Under pressure of the compressed operating slide spring, counterrecoil now begins.

As the bolt moves forward, its front face comes in contact with the top cartridge and slides it forward into the chamber, at the same time riding over the remaining rounds. The hammer rides on the bottom of the bolt and tends to follow it but is caught and held in the cocked position by the sear. When pressure on the trigger is released, the lip of the sear returns to its normal position while the hammer spring gives a slight forward motion to the hammer which pivots just enough to push the sear slightly backward and cause its after end to ride over the trigger lip, completing the cocking action. (This is the reason for the elongated hole in the sear which can be seen in figure 1–6.) If the trigger is held back after firing, the after end of the sear cannot rise above the trigger lip and the cocking action cannot be completed. In this manner full-automatic fire is prevented.

As the bolt starts into battery position, the spring-loaded extractor rides over and engages with the rim of the cartridge case, while the head of the case compresses the ejector against its spring into the bolt face. The bolt operating lug is cammed downward by the rear surface of the cam recess in the slide, rotating the bolt clockwise, engaging the locking lugs of the bolt with the receiver, and locking the bolt in the firing position. The operating slide continues to move forward about $5/16$ inch until the after end of the straight section of the slide recess contacts the operating lug. The carbine is now ready to be fired again and the cycle is repeated each time the trigger is pressed until the magazine is empty.

The Carbine M2, when set for semiautomatic fire, operates in the same manner as the M1. Some of the parts of the M2 differ slightly from those used in the M1, but only three parts are added to permit full-automatic fire: a disconnector, a disconnector lever assembly, and a selector. The disconnector bears against the sear and is attached to one end of the disconnector lever. When the selector is set for automatic fire, the other end of the lever rides against the operating slide, and when the slide is completing its last $\frac{5}{16}$-inch forward travel, AFTER THE BOLT IS IN BATTERY, a cam surface on the slide cams the forward end of the disconnector lever down. The resulting movement of the disconnector against the sear releases the hammer to fire the round and the operating cycle is repeated as long as the trigger is held depressed and ammunition remains in the magazine. When set for semiautomatic operation, the disconnector is in an inoperative position and the disconnector lever does not bear against the slide.

Caution: Always release the trigger when shifting to full-automatic operation or the weapon will fire as the shift is made.

Safety Features

SAFETY.—The safety is located in the trigger housing just forward of the trigger guard and is in the form of a cylinder with a notch. It either clears or blocks the forward end of the trigger, depending upon its position. Old type safeties snapped from side to side; the Army has replaced all safeties of this type with a newer design, but the old type may be found in Navy carbines. The new type safety rotates in the trigger housing instead of moving from side to side. It has a small projection or tang to permit easy operation, and is retained in either position by a spring and plunger. When the tang is vertical the safety is in the ON position and the trigger blocked; when the tang points to the rear the safety is OFF.

FIRING PIN TANG.—The camming action of the firing pin tang and a section of the receiver (the receiver bridge) has been mentioned under OPERATION. When the bolt is fully locked, a cutout section of the reciever bridge allows the firing pin to be driven forward into the primer. But if the bolt has not rotated to the completely locked position, the cam surface of the bridge bears against the firing pin tang and prevents forward travel of the firing pin.

CAM SURFACE ON BOLT.—The after end of the bolt has a cam surface so arranged that when the bolt is locked the hammer can strike the firing pin. If the bolt has not completely rotated to the locked position, the hammer will strike the cam surface of the bolt and not the firing pin. It can be seen that through the action of the bolt cam surface, together with that of the firing pin tang against the receiver bridge, it is virtually impossible for the carbine to be fired unless the bolt is in battery.

BROWNING AUTOMATIC RIFLE, CALIBER .30, M1918A2

The Browning Automatic Rifle, or "BAR," is an air-cooled, gas-operated, magazine-fed shoulder weapon of the type which is often called a light machine gun in foreign countries. It was designed in 1917 by John M. Browning and the first model (the Model 1918) was adopted the year following. The M1918 was intended to be held and fired in the same manner as a rifle and was without any form of mount or rest. Experience showed that any attempt at accuracy was hopeless under such conditions, therefore later models (M1918A1 and the current M1918A2) were equipped with a folding bipod rest near the muzzle and a butt plate hinged to fit over as well as against the shoulder. The original model of the BAR weighed about 15½ pounds; the M1918A1 weighed approximately 16¼ pounds; and the M1918A2 weighs over 19 pounds. However, this is still lighter than any comparable foreign weapon.

Both the BAR M1918 and M1918A1 could be fired either full-automatic or semiautomatic but the M1918A2 can be fired only fully automatic. The M1918A2 has two separate rates of fire which can be selected by the operator: the fast rate of fire is 500–600 rounds per minute while the slow rate is 300–350 rounds per minute. The fast rate of fire, generally speaking, is too fast for normal land operations and is used mostly for antiaircraft firing. The slow rate is usu-

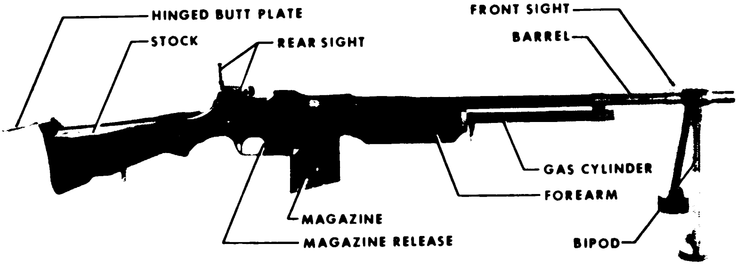


Figure 1–7.—Browning Automatic Rifle, Caliber .30, M1918A2.

ally better for most combat firing since the muzzle has much less tendency to climb off the target. Since the gun fires the regular .30 caliber rifle and machine gun ammunition, the BAR is very useful in jungle warfare where targets are not always visible and when greater penetration than is possible with submachine bullets is desired. The rate of fire is governed by the change lever, located on the left side of the receiver just above the trigger. Setting the change lever at "S" (pointed aft) renders the gun safe, setting the lever at "A" (vertical) permits the fast rate of fire, while a setting of "F" (pointed forward) gives the slower rate of fire. When firing at the slow rate, there is a distinct halt between shots.

A certain number of BAR's are issued to Navy landing parties and construction battalions, but the gun is not widely used in the Navy as compared to some of the other types of small arms. This text does not describe detailed functioning.

The gas port is on the underside of the barrel, six inches from the muzzle. Gas enters the gas cylinder through the port, strikes the piston and drives the piston and slide rearward. The bolt, which has been locked during firing by means of the bolt lock engaging a recess in the receiver (note the hump atop the receiver in fig. 1–7), is unlocked and carried to the rear by the slide. As this is done, the empty case is extracted and ejected and the recoil spring under the barrel is compressed. As the slide strikes a buffer assembly in the stock, rearward movement is stopped and if the trigger has been released, the sear engages with the action and holds it in the cocked, rearward position. Note that the BAR is an "open bolt" weapon and that while it is being operated the only time the bolt is closed is at the moment of firing. This permits cooling air to circulate through the barrel between bursts.

When the trigger is pressed, the recoil spring drives the action forward, feeding the next cartridge from the magazine into the chamber, locking the bolt, and allowing the hammer to strike the firing pin.

The magazine holds 20 rounds and is inserted in the bottom of the receiver just forward of the trigger guard. The gun is cocked by means of the operating handle on the left side of the receiver which is pulled back to retract the bolt and slide to the cocked position, and which should then be pushed forward to its normal position. The rear sight is graduated to 1,600 yards although the effective range is about 600 yards.

Following is pertinent data on the BAR M1918A2:

Weight, complete with bipod and magazine	**19.4 pounds**
Length	**47.8 inches**
Length of barrel	**24 inches**
Rifling	
Number of grooves	**4**
Right-hand twist, one turn in	**10 inches**

U. S. RIFLE, CALIBER .30, M1

The M1 replaced the old bolt-operated M1903 as the standard United States service rifle, and is frequently referred to as the "Garand" after its inventor, John C. Garand. It is a clip-fed, gas-operated, air-cooled, semiautomatic shoulder weapon which is normally equipped with a leather or webbing gun sling. The following is general data on the rifle M1:

Weight	**9.5 pounds**
Weight with leather sling	**10.3 pounds**
Weight with bayonet and leather sling	**11.2 pounds**
Length (rifle only)	**43.6 inches**
Length of barrel	**24 inches**
Rifling	
Number of grooves	**4**
Right-hand twist, one turn in	**10 inches**
Maximum effective range (ground target)	**400 yards**

The M1 rifle is used in the Navy for landing forces, marksmanship training, and recruit training. The cartridge clip

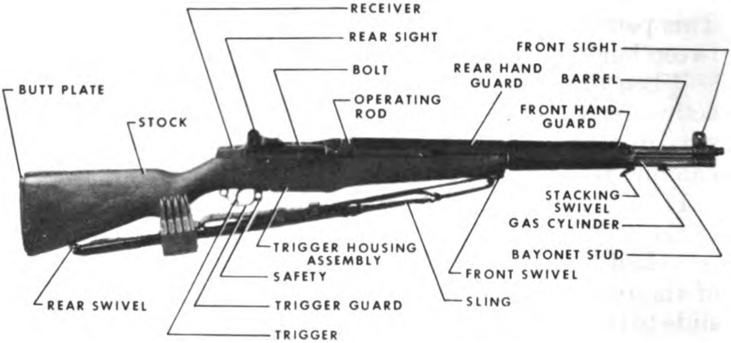


Figure 1–8.—U. S. Rifle, Caliber .30, M1.

holds eight rounds in two staggered rows (fig. 1–8) and the clip is inserted in the rifle with the cartridges. When the last round is fired, the empty clip is ejected, while the bolt remains open as an indication that the weapon is empty.

The functioning of the rifle is quite similar to that of the carbine. However, the gas port to the gas cylinder is much nearer the muzzle, being located in the underside of the barrel directly under the front sight. Gas pressure from the burning propellant enters the cylinder and forces the piston, operating rod and its spring to the rear. After 5⁄16-inch free play (to allow the bullet to clear the muzzle and gas pressure to drop), the operating rod contacts the operating lug on the bolt and rotates the bolt to unlock its two lugs from their recesses in the receiver.

The operating rod continues to the rear, carrying the bolt with it. During this rearward travel the following operations are performed:

1. The empty case is withdrawn from the chamber and ejected from the receiver.
2. The hammer is rotated down and back to the cocked position, where it is caught and held.
3. A new round in the clip is forced upward by the magazine follower into position to be fed into the chamber.
4. The operating rod spring is compressed.

When the bolt and operating rod reach the end of rearward travel, they start forward on counterrecoil, driven by the expanding operating rod spring. The new round is fed into the chamber by the bolt, which is then rotated into the locked or battery position by the cam surface of the operating rod. This leaves the rifle ready to fire again.

The safety is located immediately forward of the trigger guard (figs. 1–8 and 1–9) and when in the ON position projects aft into the space enclosed by the trigger guard.

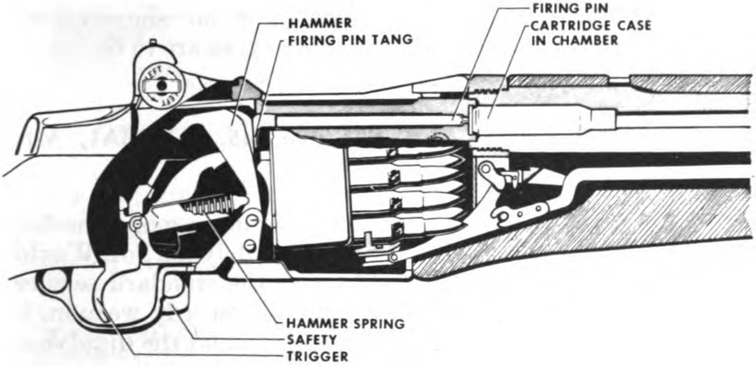


Figure 1–9.—U. S. Rifle, Caliber .30, M1—phantom and sectional view.

When ON, the safety positively locks both hammer and trigger. In addition, the M1 rifle has the same safety features to prevent out-of-battery firing as the carbine: the bolt must be completely locked or the tang of the firing pin (fig. 1–9) will not line up with a notch in the receiver bridge directly beneath it. This prevents full travel of the firing pin when struck by the hammer so the chambered round will not be fired. In addition, a cam surface on the rear face of the bolt projects into the path of the hammer so that it cannot strike the firing pin unless the bolt has rotated into the fully locked position.

SUBMACHINE GUNS

Submachine guns—generally called "machine pistols" or "machine carbines" in Europe—are short-range automatic weapons normally fired from the shoulder at ranges seldom greater than 100 yards. They almost invariably fire pistol ammunition and employ blowback operation; all American military submachine guns fire .45 caliber pistol ammunition.

These weapons are particularly adapted to close combat and were used extensively during the jungle fighting in the Pacific during World War II.

The most famous of these weapons, and the one to which the term "submachine gun" was first applied, is the Thompson Submachine Gun or "Tommy Gun." However, the Thompson is being gradually replaced in the armed forces by the M3 or "grease gun" series which is far simpler and cheaper to manufacture and since both types are to be found in the Navy, a discussion of each follows.

Thompson Submachine Guns, Caliber .45, M1928A1, M1, and M1A1

These are air-cooled, blowback-operated, magazine-fed shoulder weapons. Prior to, and in the early part of, World War II, the Thompson M1928A1 was the standard service submachine gun. While an excellent and sturdy weapon, it is expensive and difficult to mass produce, and the disadvantages led to the adoption of a simplified version, the M1, which in turn was further modified and became the M1A1. The M1A1 is the type most frequently seen and is shown in figure 1–10; the M1928A1 is similar in appearance except for the following features:

1. The bolt handle (or actuator knob) of the M1928A1 is on top of the receiver, rather than the side.
2. The M1928A1 has cooling fins on the after half of the barrel.
3. The M1928A1 has a recoil compensator on the muzzle (this device is known as a Cutts compensator).
4. The M1928A1 has an adjustable aperture rear sight, graduated to 600 yards and equiped with a 50-yard open battle sight. The M1 and M1A1 have a fixed aperture rear sight which cannot be adjusted.

The bolt of the M1928A1 contains a locking device which theoretically locks the breech at the moment of firing; this locking feature was found to be unnecessary and was eliminated in the later types (M1 and M1A1). In addition, the stock of the M1928A1 is easily slipped off the frame, while the stock of the M1 and M1A1 is secured to the gun with screws. M1928 may use a box magazine of either 20- or 30-round capacity, or a 50-round drum; other types use only

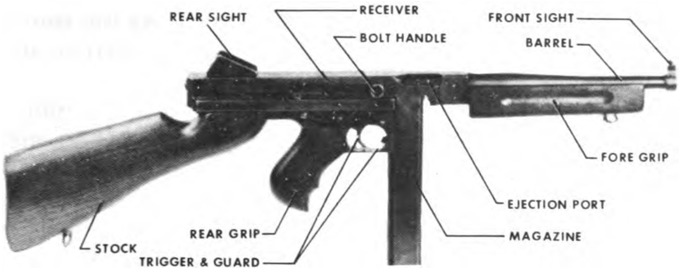


Figure 1–10.—Thompson Submachine Gun, Caliber .45, M1A1.

a box magazine of either 20- or 30-round size. Following is other pertinent data on all three models:

Overall length (approx.)	32 inches (without compensator)
Weight with filled 30-round magazine.	
M1928A1	11.3 pounds
M1A1	10.5 pounds
Length of barrel	10.5 inches
Rifling	
Number of grooves	6
Right-hand twist, one turn in	16 inches
Type of fire	Automatic or semiautomatic
Rate of fire	
M1928A1	600–725 rounds per minute (much higher in some commercial models)
M1 and M1A1	700–800 rounds per minute
Muzzle velocity	920 f. p. s.
Maximum range	1,760 yards
Maximum effective range	300 yards

The Thompsons, like BAR's are "open bolt" weapons—that is, the bolt is held open by the sear when in the cocked position and is closed only at the moment of firing. This permits cooling air to circulate through the bore between bursts or shots.

The M1 and M1A1 differ only in the construction of the bolt. The M1 has a movable firing pin which is driven forward to strike the primer at the instant the bolt goes into battery (the same method used by the M1928A1). The bolt of the M1A1 is simplified by having the firing pin fixed; it is simply a projection on the face of the bolt. As the round is chambered, the bolt is carried far enough forward to strike and fire the primer.

Just above the pistol grip, on the left side of the gun, are two levers. The FIRE CONTROL lever may be set at either SINGLE or FULL AUTO to give the type of fire desired, while the SAFETY may be set at either SAFE or FIRE. Neither lever may be moved unless the bolt is cocked.

In operation, a loaded magazine is inserted just ahead of the trigger guard. The bolt may be left in the forward position or cocked, but in either case the safety should be in the SAFE position unless the gun is to be fired immediately. To fire, the bolt is moved to the cocked position, the fire control lever placed in the desired setting, and the safety placed on FIRE. When the trigger is pressed, the sear is depressed, the bolt released, and driven forward by its compressed recoil spring. As the bolt goes forward, it feeds a round from the magazine into the chamber, the extractor on the bolt snaps around the extracting groove of the cartridge, and the firing pin strikes and fires the primer.

As the cartridge is fired, pressure from the gases produced forces the bolt to the rear against pressure of the recoil spring. After about two inches of bolt travel, the ejector throws the empty case to the right, through an opening in the receiver. As the bolt clears the magazine, the magazine follower and spring force a new round up into position to be fed into the chamber. The bolt continues to recoil another 1¾ inches, when any remaining energy is absorbed as it strikes a buffer.

If the fire control lever is set on SINGLE, the sear will have returned to position to engage the sear notch in the bolt at the end of its recoil, thus holding the bolt open and ready to repeat the cycle when the trigger is released and pressed again. If the fire control lever is set on FULL AUTO, the sear will be held down as long as the trigger is pressed, and the cycle of operation will be repeated as long as ammunition remains in the magazine. When the last round in the magazine is fired, the bolt remains open.

Caution: These weapons are not considered safe when a loaded magazine is in place and the bolt is forward, unless the safety is in the SAFE position. If the gun is dropped on the butt from a height of 18 inches or more, the inertia of the bolt is sufficient to move the bolt far enough aft to pick up a round and fire it.

Submachine Gun, Caliber .45, M3A1

The M3A1 is an air-cooled, blowback-operated, magazine-fed shoulder weapon which, though crude in appearance, is compact, rugged, low in cost, and simple to manufacture. For these reasons it is replacing the Thompson models as the service submachine gun.

The M3A1 is constructed entirely of metal with a telescoping stock made of a single piece of formed steel rod, the ends of which are drilled and tapped to receive a bore brush so that the stock may be used as a cleaning rod. The gun has no provision for semiautomatic fire but the very low cyclic rate permits a gunner to fire single shots after a little practice. It should be noted that the rate of fire was deliberately slowed down to 450 rounds per minute, which approaches an ideal rate for a submachine gun.

An unusual feature of this gun is the hinged cover over the ejection port (fig. 1–11) which must be open to fire, since it is also the safety. When the cover is down, the bolt is locked in either the open or closed position. In the closed position, the safety enters a hole in the bolt (fig. 1–12) and prevents movement to the rear. In the open position, the safety bears against the rear of the cocking slot, preventing

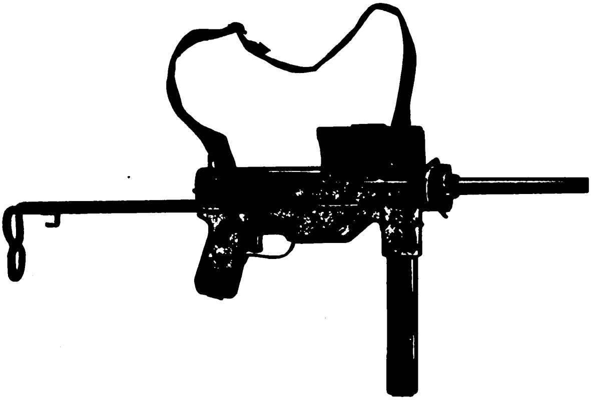


Figure 1–11.—Submachine Gun, Caliber .45, M3A1.

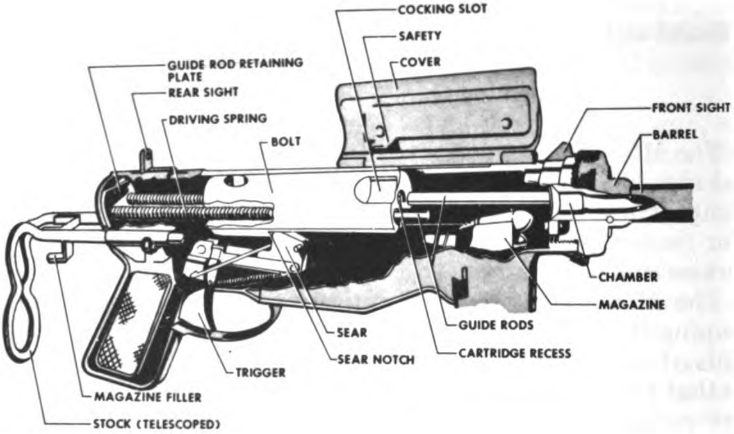


Figure 1–12.—Cutaway view of Submachine Gun M3A1.

forward motion. The cover also protects the bolt and keeps dirt out of the action.

The M3A1 cannot be cocked unless the cover is open, since cocking is done by inserting a finger in the cocking slot shown in figure 1–12 and drawing the bolt to the rear until it is caught by the sear. An earlier model, the M3, does not have this feature but instead is cocked by means of a retracting handle on the right side of the gun, just forward of the trigger. Like the Thompson guns, the M3A1 is an "open bolt" weapon. However, the bolt does not remain open when the last round in the magazine has been fired.

Following is data of the M3A1:

Overall length (stock extended)	29.8 inches
Weight with loaded 30-round magazine	10.25 pounds
Length of barrel	8 inches
Rifling	
Number of grooves	4
Right-hand twist, one turn in	16 inches
Rate of fire	450 r.p.m.
Muzzle velocity	900 f.p.s.
Maximum range	1,700 yards
Maximum effective range	200 yards

The M3A1 is loaded by drawing the bolt back to the cocked position, closing the cover to lock the bolt, and then inserting the 30-round magazine until caught by the magazine catch. To fire, lift the cover to unlock the bolt and press the trigger.

When the trigger is pressed, the sear is moved downward, releasing the bolt which is driven forward by the two compressed driving springs (fig. 1–12). As the bolt passes over the magazine, the uppermost cartridge is pushed into the chamber. When the cartridge is fully seated its base protrudes slightly from the chamber, while the bolt continues forward to strike the primer with the fixed firing pin. At the instant of firing, the cartridge is enclosed by the chamber and cartridge recess of the bolt, and the rim is engaged by the extractor.

When the cartridge is fired, chamber pressure reaches its maximum almost immediately, but by the time the inertia of the heavy bolt and the resistance of the driving springs are overcome, pressure has begun to decline. The bolt moves to the rear with the empty case held by the extractor; as the bolt passes over the ejector the case is cammed upward and deflected out of the ejector port by the ejector and extractor (fig. 1–12).

The bolt continues to the rear, compressing the driving springs, until stopped by the guide rod retaining plate at the rear of the receiver. The sear notch passes over the sear; if the trigger has been released the sear engages the notch immediately after the bolt starts forward and holds the bolt in the cocked position. If pressure is maintained on the trigger, the sear remains depressed and the bolt starts forward on counterrecoil. The cycle is repeated as long as ammunition remains in the magazine.

Caution: Both the M3 and the M3A1, because of their simplicity and low cost, lack the numerous safety features of other small arms. The guns are safe ONLY when the magazine is out and the bolt is forward. If either of these weapons are carried with a loaded magazine in place, bolt forward and cover down, dropping the gun may jar the cover open and the bolt far enough aft to pick up and fire a round. Therefore:

Load the gun only when ready to fire.

Unlock the loaded gun only when it is raised to fire.

SHOTGUNS

All shotguns are procured from commercial manufacturers and are used by the Navy for security and special training purposes. Short-barreled riot guns are used only for arming watchstanders, guarding prisoners, and the like, while sporting type shotguns have been used in the gunnery training of pilots and aircrewmen. Both types are very similar and often differ only in barrel length. All military shotguns (except some survival kit weapons) are 12 gage.

The choke of a shotgun refers to the boring of the barrel and choking is accomplished by boring the barrel so that the diameter of the bore near the muzzle is slightly less than the diameter of the rest of the bore. The degree of choke ranges from FULL CYLINDER to FULL CHOKE and is measured by the dispersion of the pellets in the shot charge at a given distance from the muzzle. This dispersion is measured in the percentage of pellets which will be contained within a 30-inch circle at 40 yards range from the muzzle and varies from 75 percent for a full choke to 40 percent for a full cylinder barrel. The charge from a full cylinder barrel (generally referred to as CYLINDER) thus has a greater spread and a correspondingly shorter effective range than the charge from a full choke barrel.

In the armed services, any shotgun with a 20-inch cylinder barrel is classed as a riot gun. Specifications call for riot guns to be equipped with bayonet stud, hand guard, and sling swivels but many have been procured without these accessories and both types are to be found in the Navy.

The standard load for riot guns is the #00 buckshot shell (the term "shell" is standard nomenclature for the shotgun cartridge). Each round contains nine pellets and each pellet is 0.34 inch in diameter; since the magazine capacity of most military shotguns is five rounds, it can be seen that the riot gun makes an extremely effective close-range weapon.

Military shotguns are of two general types, the slide or pump action and the semiautomatic. Both types have a fixed tubular magazine located beneath the barrel, as shown in figure 1–13.

Slide action shotguns are operated manually by moving the slide handle smartly and fully, backward and forward. During the rearward movement the breech is unlocked, the fired shell extracted and ejected, and the hammer cocked. During the forward movement a live round is fed from the magazine into the chamber and the breech locked, permitting the trigger to be pressed for another shot. The following 12-gage riot guns use slide-operated manual operation: Remington M10 and M31, Winchester M97 and M12. The M97 is unique among these in that it has an external hammer, while other models have hammers completely enclosed by the receivers and are known as "hammerless."

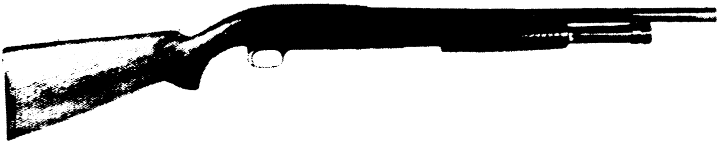


Figure 1–13.—Winchester M12 Riot Gun.

Semiautomatic or autoloading shotguns are recoil operated. The first round must be fed from the magazine into the chamber by manually operating the action, after which the operation is automatic each time the trigger is pressed. The force of recoil unlocks, extracts, ejects, cocks the hammer, chambers the fresh round, and locks the breech. The Remington M11 is a typical recoil-operated shotgun and in riot-gun form is often seen in the Navy.

NEW DEVELOPMENTS

Currently under development by the Army are new rifles, one of which will replace the M1 as the standard service rifle. The M1 was adopted in 1936 and while an excellent weapon, it has bad features, one of which is excessive weight. Whichever experimental rifle is finally adopted, it will weigh less than eight pounds. It will be capable of full-automatic fire at a rate of about 700 rounds per minute as well as the usual semiautomatic fire and will be chambered for the new shorter, lighter T65 caliber .30 cartridge (see chapter 5, volume 1).

The new rifle, when adopted, will probably replace the carbine and submachine gun, and possibly other weapons, as well as the rifle. However, it should be remembered that this change will take place gradually over a period of years, and that present small arms will remain in service for a long time to come.

SAFETY PRECAUTIONS

Small-arms safety precautions, like all safety precautions, are largely a matter of common sense. Every gun should be considered loaded until proven otherwise by examination; never trust your memory or anyone else's memory in this respect. To THINK a gun is unloaded can be fatal. Be positive.

NEVER point a firearm at anyone or anything you do not intend to shoot, or in any direction where accidental discharge might do harm. When checking operation or releasing spring tension, point the weapon upwards or in some safe direction before pressing the trigger. Never place the finger inside the trigger guard unless ready to fire.

Do not work on a weapon you do not thoroughly understand. Ask a senior ordnanceman or other qualified personnel to instruct you if possible; otherwise refer to the proper technical publication. Never use force in disassembling and assembling small arms. They are all so constructed that undue force is unnecessary if parts are properly assembled or removed.

Safety features should be frequently tested for proper functioning. For obvious reasons, an inoperative safety device is more dangerous than no safety device at all.

In weapons with detachable magazines, always remove the magazine as the first step in unloading or clearing a stoppage. It should be noted that in ALL magazine-fed weapons the shape, position, and condition of the magazine lips are extremely critical, and if dented will interfere with proper feeding of the cartridge into the chamber. The majority of stoppages in magazine-fed weapons is due to faulty magazines and consequently care must be taken when handling them not to cause damage.

Before loading ammunition into the weapon, check for dirt, oil, grease, malformation, loose bullets, or other defects.

Check the bore prior to firing to be sure it is free of foreign matter or obstructions. If during firing there is any indication of misfire or weak charge, make sure the bullet is not lodged in the bore. An obstructed bore will cause a serious accident when the next round is fired.

To minimize danger from hangfire, wait 10 seconds after a misfire, then clear the weapon quickly. If the weapon cannot be cleared quickly and the barrel is hot, DANGER OF COOK-OFF EXISTS. Leave the round in the chamber, point the weapon in a safe direction, and allow it to cool before removing the misfired round.

Special Precautions for Pistols and Revolvers

Automatic pistols in the hands of inexperienced or careless persons are largely responsible for the saying "It's always the unloaded gun that kills." It is a fact that many accidental deaths and injuries are due to a mistaken belief that removing the magazine of a pistol (or other magazine-fed weapon) is all that is necessary to unload it. Nothing could be further from the truth. To completely unload a pistol or other magazine-fed weapon and render it safe to handle, it is necessary to not only remove or empty the magazine, but also to MAKE ABSOLUTELY CERTAIN THE CHAMBER IS EMPTY. The only way this can be done, when handling the caliber .45 pistol, is to pull back the slide and inspect the chamber either visually or by feel if it is dark. This should be done AFTER the magazine is removed, and with the muzzle pointed upward. Of course, if the chamber is loaded, the round will be extracted and ejected when the slide is operated. "I didn't know it was loaded" is never an excuse for the accidental discharge of a weapon—especially for the ordnanceman.

When handling revolvers, a simple visual inspection is sufficient to determine if any chambers in the cylinder are loaded.

Keep hammer fully down when pistol or revolver is not loaded.

When the pistol is cocked, keep the safety lock in the ON position until ready to fire.

Special Precautions for Carbines

When firing M2 and M3 carbines, make sure the selector is set correctly for the type of fire intended. Unexpected automatic fire, when single fire is expected, can cause an accident.

Special Precautions for Shotguns

Although military shotguns are 12 gage, commercially manufactured 16- and 20-gage shells, being smaller, can be loaded into the 12-gage chamber. The 20-gage shell is particularly dangerous in this respect, since it is just the right size to hang up in that portion of the bore known as the "forcing cone," immediately ahead of the chamber. Although this completely obstructs the bore, the 20-gage shell is far enough forward in the barrel to allow a 12-gage round to be chambered; if the chambered round is fired the barrel almost invariably bursts, seriously damaging the gun and often injuring the shooter. For this reason, care must be taken that shells of various gages are not mixed and only the proper size shell is loaded into the gun.

In addition, the proper chamber for a round is slightly longer than the shell, so that when the gun is fired there will be room for the paper case to open without constricting the bore. It is possible to chamber a round too long to be fired in the gun and if such a shell is fired, the open end of the case will constrict the bore, raise the pressure, and blow up the gun. Military shotguns, and most commercial models as well, have a chamber length of 2¾ inches, so all shotgun ammunition procured for the armed services is designed to fit this size chamber. Never use shells intended for a longer chamber.

QUIZ

1. Caliber of a weapon is measured across the bore
   a. from groove to groove
   b. from land to land
   c. from land to groove
   d. in tenths of inches
2. The part which pulls the empty case from the chamber is called a/an
   a. sear
   b. ejector
   c. breech
   d. extractor
3. The caliber .45 Model 1911A1, pistol is
   a. magazine fed and gas operated
   b. magazine fed and recoil operated
   c. clip fed and gas operated
   d. clip fed and recoil operated
4. What forces the Colt .45 slide stop UP to engage the slide when the last round is fired?
   a. Main spring
   b. Recoil spring
   c. Magazine follower
   d. Slide spring
5. The safety lock of the Colt .45 in the ON position blocks any movement of the
   a. trigger
   b. disconnector
   c. hammer
   d. sear
6. Which leaf of the Colt .45 sear spring puts tension on the grip safety?
   a. Center
   b. Left
   c. Right
   d. None of the above
7. The caliber .38 revolver is
   a. recoil operated
   b. gas operated
   c. manually operated
   d. blowback operated
8. The maximum effective range of the caliber .38 revolver is
   a. 50 yards
   b. 75 yards
   c. 100 yards
   d. 300 yards

9. In firing single action, the hammer of the caliber .38 is cocked by the
    a. sear
    b. thumb
    c. trigger
    d. bolt

10. Which of the devices below is NOT a safety device of the caliber .38?
    a. Bolt
    b. Rebound slide
    c. Hammer block
    d. Sear

11. What locks the cylinder of the caliber .38 in the firing position?
    a. Cylinder stop
    b. Hand
    c. Bolt
    d. Cylinder lock

12. The U. S. Carbine, Caliber .30, M1, is
    a. gas operated and magazine fed
    b. recoil operated and magazine fed
    c. gas operated and clip fed
    d. recoil operated and clip fed

13. How far does the operating slide of the carbine move before unlocking the bolt?
    a. ¼ inch
    b. 5/16 inch
    c. ⅝ inch
    d. ⅞ inch

14. What holds the carbine's hammer cocked?
    a. Hammer
    b. Trigger
    c. Half-cock notch
    d. Sear

15. The safety on the carbine blocks the
    a. hammer
    b. trigger
    c. sear
    d. hammer and sear

16. Which setting of the change lever of the Browning Automatic Rifle, Caliber .30, will give slow rate of fire?
    a. "S"
    b. "A"
    c. "F"
    d. "T"

17. The effective range of the BAR is about
    a. 300 yards
    b. 400 yards
    c. 500 yards
    d. 600 yards

18. The Rifle, Caliber .30, M1, is
    a. clip fed and gas operated
    b. clip fed and recoil operated
    c. magazine fed and gas operated
    d. magazine fed and recoil operated

19. The safety on the M1 rifle locks the
    a. sear and hammer
    b. hammer and trigger
    c. sear and trigger
    d. bolt and sear

20. The Thompson Submachine Gun, Caliber .45, fires
    a. at the instant the bolt goes into battery
    b. out of battery
    c. after the bolt locks in battery
    d. when the bolt is locked to the rear

21. The Submachine Gun, Caliber .45, M3A1, is
    a. blowback operated
    b. manually operated
    c. recoil operated
    d. gas operated

22. The rate of fire (rounds per minute) of the Submachine Gun Caliber .45, M3A1, is
    a. 350
    b. 550
    c. 450
    d. 600

23. When checking operation of a weapon
    a. point the weapon at a moving target
    b. point the weapon down
    c. aim at a target at least 500 yards away
    d. point the weapon upwards

24. To minimize danger from a hangfire, you should wait after a misfire at least
    a. 3 seconds
    b. 5 seconds
    c. 10 seconds
    d. 15 seconds

25. A shotgun with a 20-inch cylinder barrel is termed a
    a. carbine
    b. skeet gun
    c. trap gun
    d. riot gun

CHAPTER 2

MACHINE GUN CALIBER .50 M2

INTRODUCTION

The Browning Aircraft Machine Gun (BAMG) caliber .50 M2 is an automatic, recoil-operated, belt-fed, air-cooled, machine gun, used in certain turret installations. It is an alternate-feed gun (fed from either right or left side) and may be mounted on either a rigid or flexible mount. After the first cartridge is loaded and the gun is charged, it will keep firing as long as the trigger is held down. While firing, all mechanical action is automatically performed by the gun itself. The rate of fire ranges from 750 to 850 rounds per minute (14 per second). The bullets leave the barrel at a speed of about 2,900 feet per second (muzzle velocity), and at a distance of four miles (the maximum range), one of these bullets will kill a man. The general appearance of the gun may be noted in figure 2–1, which shows a top and side view of the complete gun.

The air-cooling effect is obtained by the circulation of air through the perforations (holes) in the barrel jacket. This system is effective for the aircraft gun because the air at high altitudes is very cold and the gun extends out into the slipstream. Machine guns designed for ground use are either water-cooled or have a heavy barrel that can withstand more heat. In addition to the aircraft gun, the M2 is produced with the water-cooled barrel (for antiaircraft use) and the heavy barrel air-cooled (for tank and field). This chapter deals only with the aircraft gun.

Firing the gun sets about 150 parts in motion. While the gun fires, parts are recoiling and counterrecoiling, locking and unlocking, compressing and expanding, pivoting, sliding, pulling, opening, and closing. Figure 2–2 shows a cutaway view of the gun.

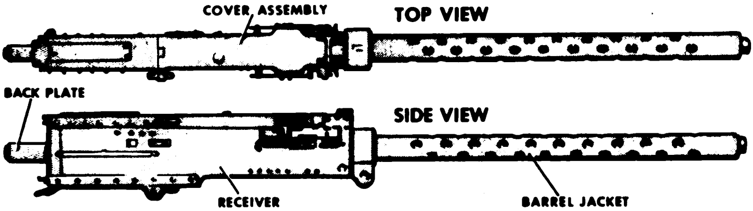


Figure 2–1.—Browning Aircraft Machine Gun, Caliber .50 M2.

At first glance, the gun and its work look very complicated and puzzling, but fortunately, the parts fall naturally into six main groups. It is easy to learn to recognize the six groups, and then to learn the parts within each group.

The BOLT GROUP shuttles from battery position to the rear of the gun and back again, draws the live rounds from the ammunition belt, loads them into the chamber, and hits them with the firing pin. It extracts empty cases from the chamber and ejects them out the bottom of the gun.

The BARREL AND BARREL EXTENSION GROUP includes the barrel and the barrel extension that screws onto it. This group also recoils, but not nearly so far as the bolt group.

The OIL BUFFER GROUP is the brake that stops the recoiling barrel group. Its main part is a sealed cylinder which is full of oil. When the barrel and barrel extension recoil, they compress a spring and drive a piston into the cylinder, forcing the oil through the two slots in the side of the piston head. The impact of the barrel and barrel extension is so powerful that all the oil is forced through the slots in a small fraction

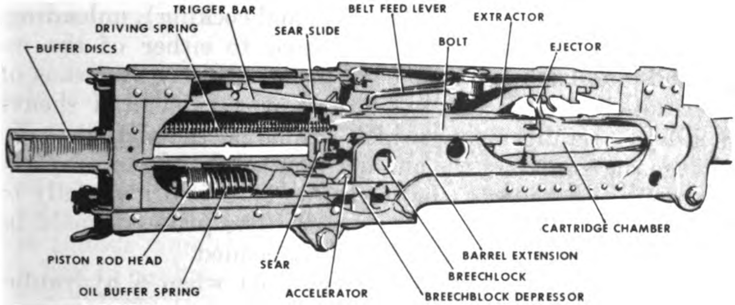


Figure 2–2.—Cutaway view of caliber .50 BAMG.

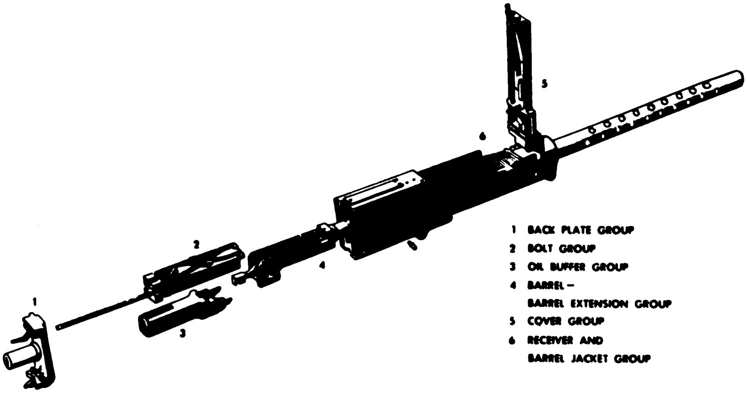


Figure 2–3.—The six groups.

of a second. During counterrecoil, the energy stored in the buffer spring forces the barrel and barrel extension into battery.

The RECEIVER AND BARREL JACKET GROUP encloses all the parts of the gun. It includes the receiver, which is a rectangular steel box holding the working mechanism, and the barrel jacket, which supports and protects the barrel.

The COVER GROUP, which encloses part of the top of the receiver does most of the work of feeding the ammunition belt into the gun.

The BACK PLATE GROUP, at the rear of the receiver, absorbs the force of the bolt's recoil.

A seventh group is often encountered and is known as the RETRACTING SLIDE GROUP. The retracting slide group provides a means of charging (loading and cocking), unloading, or clearing stoppages. It is secured to either of the receiver side plates and may be operated directly by means of a handle, or indirectly by means of a cable and sheave (pulley) arrangement, which replaces the handle. To charge the gun after the ammunition belt has been properly placed in the feedway, the retracting slide is drawn fully to the rear and then sharply released. The process should be repeated to insure that the chamber is loaded.

A retracting slide group is not used when a hydraulic, pneumatic, or other mechanical type gun charger is installed. Gun chargers are discussed in chapter 3.

General Data (approximate specifications):

Weight of gun	61 pounds.
Weight of bullet	712 grains (1.62 oz.).
Weight of powder charge	250 grains (0.57 oz.).
Weight of cartridge	4.20 oz.
Weight of 100 cartridges in metallic links	30.25 pounds.
Weight of barrel	10 pounds.
Length of barrel	36 inches.
Number of lands	8.
Twist—right-hand	1 turn in 15 inches.
Overall length of gun	56.125 inches.
Muzzle velocity	2,845 ft. per second. (1,940 miles per hour).
Rate of fire	750 to 850 rounds per min.
Maximum range	7,200 yards (4.1 miles).

BASIC OPERATION

These simplified diagrams of the M2 give a general picture of how the gun operates. They show the two recoiling groups—bolt group and barrel and barrel extension group—going through a complete cycle from battery position through recoil and counterrecoil. Of course, many parts not shown here are functioning at the same time.

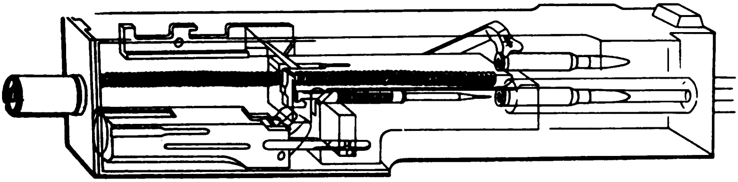


Figure 2–4.—In battery.

In figure 2–4 the bolt is in battery, firing pin assembly held cocked by the sear and ready to fire the live round in the chamber. The ammunition belt is held in the feedway with the next round grasped by the extractor (part of the bolt group). Note that in the BAMG the extractor does not extract fired cases from the chamber, but instead draws live rounds from the belt and positions them on the face of the bolt to be chambered during counterrecoil. Empty cases are extracted from the chamber by a T-slot on the face of the bolt. The bolt and barrel extension are locked together

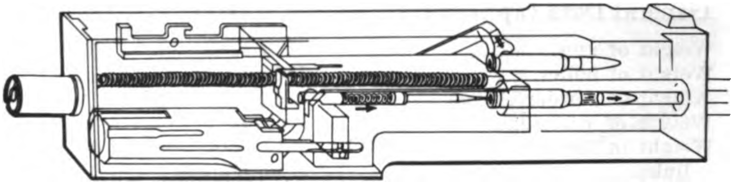


Figure 2–5.—Fire.

by the breech lock, which is held in place by a cam on the bottom plate of the received.

The firing pin can be released one of two ways: by a trigger bar which presses down directly against the sear and which is operated either manually or by a solenoid trigger control, or by a solenoid trigger control which presses inward against the sear slide, camming the sear downward. Either method results in the sear being depressed far enough to disengage the sear notch from the firing pin shoulder, freeing the firing pin and allowing it to be driven forward by its compressed spring to strike the primer and fire the chambered round. Recoil action now commences as the burning propellant exerts force against the face of the bolt.

Since the bolt, barrel, and barrel extension are locked together, they recoil as a unit for about ¾ inch, at which point two depressors on the oil buffer body start to cam the breech lock downward out of engagement with the bolt (since the barrel extension has moved rearward, the breech lock is clear of its cam). Further travel rearward completes the unlocking and the bolt continues to recoil while the barrel extension is stopped by the oil buffer group. The barrel and extension are kept locked to the rear by the accelerator, against the pressure of the compressed oil buffer spring.

The full travel of the bolt during recoil is 7⅛ inches. During this travel the following actions are accomplished:

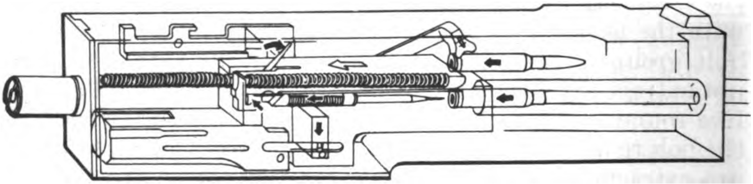


Figure 2–6.—Recoil.

1. The empty case, held in the T-slot of the bolt, is drawn from the chamber.
2. The belt feed lever, one end of which rides in a groove on top of the bolt, moves the belt feed slide outward from the cover to engage a new round in the belt.
3. The next live round to be fired is pulled from the belt by the extractor, and while held by that part, is moved into the T-slot directly above the extracted fired case.
4. The cocking lever pivots around its pin, pulling the firing pin assembly back against its spring and hooking it onto the sear notch. A cam surface on the receiver top plate, in which the upper end of the cocking lever rides, accomplishes the pivoting action.
5. The double driving spring, which will drive the bolt forward on counterrecoil, is compressed.

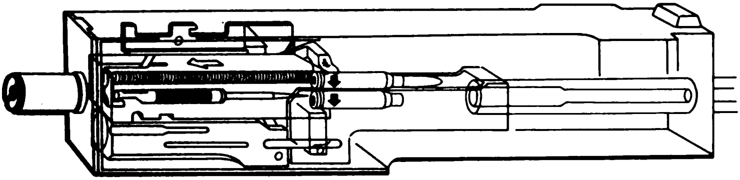


Figure 2–7.—Full recoil.

At the end of its recoil movement, the bolt strikes and is cushioned by the buffer assembly in the back plate. It bounces off the buffer plate, and driven by the compressed driving springs and buffer disks, starts forward on counterrecoil.

As the bolt travels forward during counterrecoil, it directly or indirectly performs the following functions:

1. The extractor, still holding the live round, is forced farther downward by a movable cam switch on the left side plate of the receiver. This action results in the live round knocking the empty case out of the T-slot and clear of the gun through the bottom of the receiver, and at the same time lines up the live round with the chamber.

2. The belt feed slide, operated by its lever riding in the groove on top of the bolt, draws the belt inward so that by the time the bolt reaches battery position a fresh round will be in position to be engaged by the extractor.

3. When the bolt has traveled about five inches forward, its lower lug strikes and pivots the accelerator tips forward, unlocking the barrel extension from the oil buffer group and allowing the compressed oil buffer spring and driving springs to push bolt, barrel extension, and barrel the rest of the way into battery. The live round is chambered, and as the barrel extension and bolt ride over the breech locking cam, it moves the breech lock (in the barrel extension) upward to lock the bolt to the barrel extension. As these two groups go into battery, two more actions are accomplished:

a. The extractor assembly is cammed upward by a cam on the side plate to engage the next round which has been brought into position by the belt feed slide.

b. The upper end of the cocking lever is pivoted to the rear, moving the lower end of the lever forward so that the firing pin assembly is free to move when released by the sear. This is not done until the bolt is locked to the barrel extension in firing position as a safety measure.

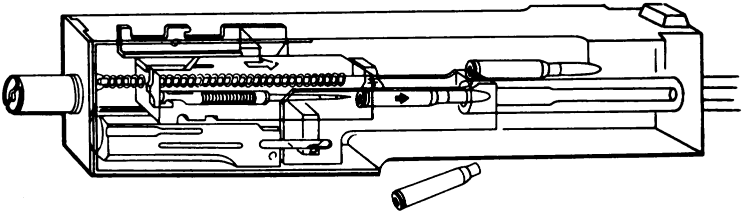


Figure 2–8.—Counterrecoil.

The gun has now completed a full cycle. If the trigger is held depressed, the sear will be depressed and the firing pin assembly released just before the barrel and extension reach the full forward position, and the cycle will be repeated.

FIELD STRIPPING

"Field stripping" is the term applied to the partial disassembly of a weapon for cleaning and maintenance and usually consists of breaking the gun down to its major groups without disassembling the groups themselves. It is the first step in taking the gun completely apart (detail stripping), and is sometimes necessary when a stoppage occurs during firing.

To field strip the .50 caliber M2, four of the six (or seven) groups are removed. The proper procedure is given below; however, there are minor variations of this method which are just as correct. To identify the parts mentioned, refer to figures 2–9 through 2–14.

1. **Raise the cover.**—Turn the cover latch and lift the rear end of the cover upward. Assuming the bolt is in battery, raise the extractor and look into the T-slot to make sure the chamber is clear. As a rule, the bolt should be forward before field stripping continues but if it is impossible (because of a malfunction) to return the bolt to battery, great care must be used in the next step. When fully in battery, the bolt T-slot bears against the breech end of the barrel and the barrel extension bears against the receiver trunnion block.

2. **Remove the back plate group.**—If the gun is not solidly secured, as for example when it is lying on a workbench, hold down the top of the receiver with one hand and place the other hand on the back plate. Pull the back plate latch lock back with the middle finger, lift up the latch with the index finger, and slide the back plate up and out of the receiver. ***Caution:*** If the bolt is in any position other than full battery, stand clear as the back plate is removed since it is possible for the compressed driving spring to shear its retaining pin and jump out as the back plate is removed. If a malfunction is holding the bolt very far out of battery, the driving spring will have enough energy to cause serious injury.

3. **Remove the driving spring assembly.**—With the thumb and forefinger of one hand, push forward on the end of the driving spring rod and at the same time move the end of the rod inboard, pulling the retaining pin out of its hole in the receiver side plate. (Never attempt to remove the driving spring assembly in this manner if the bolt is not in battery.) After the retaining pin is clear of its hole, the driving spring assembly may be removed from the bolt.

4. **Remove the bolt stud.**—The bolt stud may be found on either side of the receiver; it is mounted on the same side as the charger or retracting slide group. The bolt stud rides in a slot cut through the receiver side plates and provides a connection between the bolt and charger. To remove it, raise the extractor assembly and pull it and the bolt to the

rear. When the bolt stud reaches the cutout portion in the middle of the slot, it may be pulled out of the gun.

5. REMOVE THE BOLT GROUP.—With one hand push the bolt group aft until it can be supported with the other hand and slide it out the rear of the receiver.

6. RELEASE THE FIRING PIN.—As described earlier, the firing pin will be cocked as the bolt is drawn to the rear. The bolt group should never be left lying around with the firing pin cocked; in order to release it, rotate the cocking lever to the rear, and using a suitable tool, press down upon the upper tip of the sear until the firing pin is released. NOTE: Be sure to rotate the cocking lever all the way to the rear or it will snap down quite hard on the fingers as the firing pin is released.

7. PULL OUT THE OIL BUFFER AND BARREL GROUPS.—To release the buffer body spring lock, which holds the oil buffer and barrel groups in the receiver, insert a pointed tool in the hole in the after end of the right receiver side plate. Push inward to disengage the spring lock from its recess in the receiver and at the same time use the other hand to push the two groups to the rear and part way out of the receiver. This is easiest done by inserting the hand through the top of the receiver so that the fingers can exert pressure against the barrel extension. NOTE: Guns in certain types of installations do not use the buffer body lock spring, in which case it is necessary only to slide the oil buffer and barrel groups to the rear with no unlocking from the receiver required.

8. SEPARATE THE OIL BUFFER GROUP FROM THE BARREL EXTENSION.—Grasp the oil buffer group, push the tips of the accelerator forward with the thumb, and pull to the rear.

9. REMOVE THE BARREL AND BARREL EXTENSION GROUP FROM THE RECEIVER.—As the barrel is pulled to the rear and out of the receiver, hold it up so that the muzzle does not drop and the barrel strike the breech lock cam as the barrel leaves the barrel jacket.

ASSEMBLY

1. REPLACE BARREL AND BARREL EXTENSION AND OIL BUFFER GROUPS.—Carefully insert the barrel into the receiver until the lower projection on the extension contacts the bottom plate. Make sure the oil buffer tube is all the way forward in the buffer body, and then grasp the buffer body in the

right hand with the index finger holding up the accelerator. Start the breech lock depressors into their guideways in the barrel extension and engage the notch in the piston rod with the barrel extension shank. Push the oil buffer group forward as far as it will go, thus rotating the accelerator rearward and locking the barrel extension to the oil buffer group. If the two groups are properly locked together, the rear of the tube will extend from the buffer body about one inch, but cannot be pulled farther out. Leave the barrel and extension protruding from the receiver for the next stop.

2. INSTALL THE BOLT AND REPLACE ALL GROUPS IN THE RECEIVER.—First, MAKE SURE THE COCKING LEVER IS FORWARD. Then engage the guide keys or ribs on the lower part of the bolt with their keyways in the barrel extension and carefully slide the bolt part way into the barrel extension. Do not slide it far enough forward to trip the accelerator and unlock the oil buffer group from the barrel extension. Insert the driving spring assembly in the bolt. Raise the barrel extension and oil buffer until clear of the bottom plate and push the groups forward until locked in position by the buffer body spring lock snapping into its recess in the receiver.

3. REPLACE THE BOLT STUD.—Position the bolt so the hole for the bolt stud lines up with the cutout portion of the slot in the receiver. Insert the stud.

4. SEAT THE DRIVING SPRING.—If gun is not solidly secured, hold the top of the receiver with one hand and with the thumb of the other, push the driving spring smartly forward. As the spring and bolt go forward, the accelerator is tripped, and barrel, barrel extension and bolt go into battery. Continue to push the rod forward, slightly compressing the springs, until the pin in the head is aligned with the elongated hole in the receiver side plate. When aligned, push the pin to the right, seating the pin in the hole.

5. REPLACE THE BACK PLATE GROUP.—After making sure all parts are clear, start the back plate into its grooves in the rear of the receiver, latch end down and buffer tube aft. Disengage the latch lock, lift the latch, and push the back plate assembly all the way down. Release the latch lock and latch, making sure the latch engages its seat under the bottom plate and is locked by the latch lock. Close the cover and the gun is completely assembled, ready for operation.

COMPLETE DISASSEMBLY AND ASSEMBLY

The instructions on the following pages give the step by step procedure for complete disassembly and assembly of the six groups. Instructions for each group are preceded by an exploded view and a list of the nomenclature and functions of all its parts. Each part in the nomenclature lists can be identified (by number) and its relative position within its group can be determined by refering to the accompanying illustration. The groups are presented in the order they are normally removed from the gun.

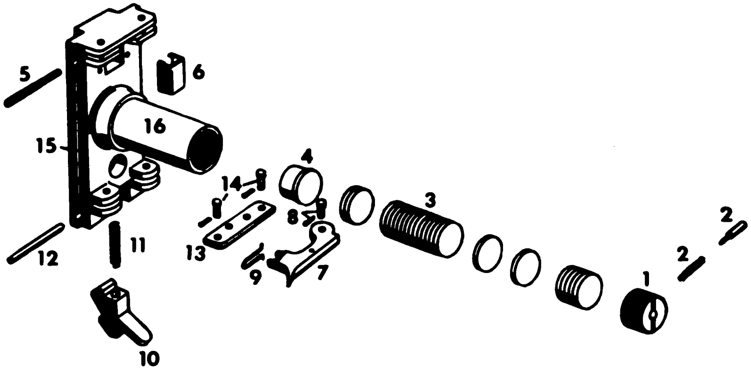


Figure 2–9.—Back plate group.

NOMENCLATURE FOR FIGURE 2–9

Nomenclature	Function
1. Buffer adjusting screw	Adjusts the pressure on buffer disks.
2. Buffer adjusting screw plunger and plunger spring.	Prevents the buffer adjusting screw from turning freely.
3. Buffer disks	Absorbs the shock of the bolt's recoil.
4. Buffer plate	Passes the shock of the bolt's recoil on to the buffer disks and prevents battering of the back plate.
5. Upper filler piece pin	Holds the upper filler piece in position.
6. Upper filler piece	Fills the trigger hole when the trigger is not installed.
7. Latch lock	Locks the latch.
8. Latch lock pin and cotter pin	The pin holds the latch lock and provides a pivot for it; the cotter pin keeps the latch lock pin in place.
9. Latch lock spring and pin	The spring, which is held in the latch lock by its pin, pushes against the latch lock, holding it in place.

NOMENCLATURE FOR FIGURE 2-9—Continued

Nomenclature	Function
10. Latch	Holds the back plate down.
11. Latch spring	Pushes against the latch to keep it locked.
12. Latch pin	Holds the latch and provides a pivot for it.
13. Lower filler piece	Provides a mounting for the latch lock.
14. Lower filler piece pins (two) and cotter pins (two).	Hold the lower filler piece in position.
15. Back plate	Encloses the back end of the receiver and keeps the oil buffer group from moving back. Also acts as rear compression point for the driving spring.
16. Buffer tube	Houses the buffer adjusting screw, buffer disks, and buffer plate.

Disassembly—Back Plate Group

Remove the buffer adjusting screw (1). While unscrewing it, wrap your fingers around it to keep the plunger and plunger spring (2) from jumping out.

Remove the buffer disks (3) and buffer plate (4) by tilting the buffer tube (16) until they fall out.

Remove the upper filler piece pin (5), then remove the upper filler piece (6).

Remove the latch lock (7) by pulling out the cotter pin and drifting out the latch lock pin (8).

Take off the latch (10) and latch spring (11) by drifting out the latch pin (12). Press the latch with your thumb so its spring will not pop out.

Remove the lower filler piece (13) by taking out the cotter pins and removing the two lower filler piece pins (14).

Assembly—Back Plate Group

Replace the lower filler piece. Insert the filler piece pins with their heads toward the top and replace the cotter pins.

Replace the latch, latch spring, and latch pin.

Replace the latch lock and insert its pin and cotter pin.

Place the upper filler piece in the slot and push the upper filler piece pin in place.

Replace the buffer plate and buffer disks.

Replace the buffer adjusting screw. (When the screw has been tightened as tight as possible it should be flush, or protruding not more than one thread).

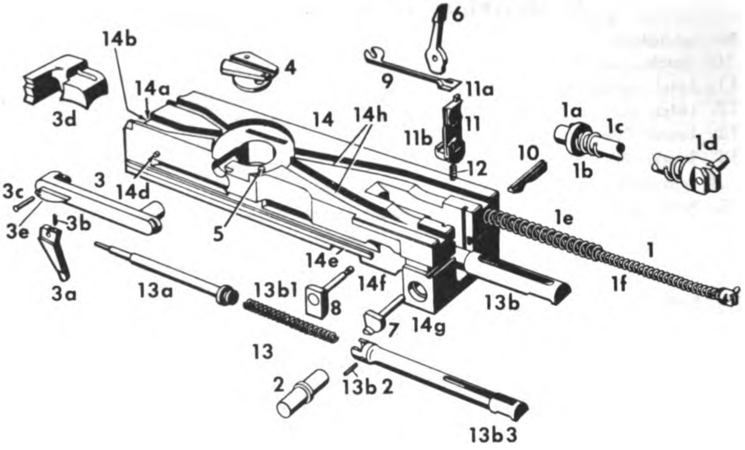


Figure 2–10.—Bolt group.

NOMENCLATURE FOR FIGURE 2–10

Nomenclature	Function
1. Driving spring rod assembly	Smooths out the action of the bolt in automatic fire and helps push it forward on counterrecoil; returns the bolt to battery position in charging.
a. Driving spring rod collar stop pin.	
b. Driving spring rod collar.	
c. Driving spring rod.	
d. Driving spring rod head and retaining pin.	
e. Outer driving spring.	
f. Inner driving spring.	
2. Bolt stud	Connects the bolt to the charger.
3. Extractor assembly	Pulls the new round from the ammunition belt and helps feed it into the chamber; ejects the last empty case.
a. Ejector	Helps support the new round for extraction from the belt and feeding into the chamber; ejects the last spent case from the T-slot.
b. Ejector spring	Holds the ejector against the round.
c. Ejector pin	Holds the ejector in place and provides it with a pivot.
d. Extractor hook	Extracts the new round from the belt by hooking into the extracting groove.
4. Bolt switch	Provides a clear track along either the right or left groove, depending on direction of feed.

NOMENCLATURE FOR FIGURE 2-10—Continued

Nomenclature	Function
5. Bolt switch stud	Keeps the bolt switch from turning.
6. Cocking lever	Cocks the firing mechanism; keeps the gun from firing too soon.
7. Cocking lever pin	Holds the cocking lever in place and provides it with a pivot.
8. Accelerator stop	Prevents accelerator tips from entering breech lock recess. Its pin provides a compression point for the firing pin spring.
9. Accelerator stop lock	Aids in holding the sear in place and locks the accelerator stop.
10. Sear slide	Pushes the sear down to release the firing pin when the gun is fired from the side.
11. Sear	Holds the firing pin back until the trigger is pressed.
a. Sear tip	Rides under the trigger bar to cam down the sear in automatic fire.
b. Sear notch	Hooks into the notch on the firing pin extension to hold the firing pin back until the trigger is pressed.
12. Sear spring	Pushes the sear up into place after each round is fired.
13. Firing pin assembly:	
a. Firing pin	Fires the round by hitting the primer.
b. Firing pin extension assembly	
(1) Firing pin spring	Forces the pin forward when released by the sear.
(2) Firing pin spring stop pin.	Holds the firing pin spring in the firng pin extension. Acts as front compression point for the firing pin spring.
(3) Firing pin extension notch.	Hooks onto the sear spring, holding the firing pin back until the trigger is pressed.
14. Bolt body	Houses the parts of the bolt group. Its two cam grooves make it possible for ammunition to be fed from either side of the gun.
a. T-slot	Extracts the spent case from the chamber; helps support the new round entering the chamber.
b. Recoil plate	Located in face of bolt. The recoil plate provides a shield of harder metal to receive the recoil of the primer.
c. Firing pin port	Provides a hole in the recoil plate which enables the firing pin to hit the primer.
d. Extractor stop pin	Stops the downward motion of the extractor assembly.
e. Breech lock recess	Provides a space for the breech lock to enter the bolt to lock it to the barrel extension.

NOMENCLATURE FOR FIGURE 2–10—Continued

Nomenclature	Function
f. Middle projection	Turns the accelerator to the rear in hand charging.
g. Lower projection	Works with the accelerator to speed up the bolt on recoil and slow it down on counter-recoil; houses the bolt stud.
h. Cam grooves	Guide the belt feed lever (of the cover group) as its lug rides in the grooves.

Disassembly—Bolt Group

Remove the extractor assembly (3) by swinging it to the rear and pulling it off the side.

Lift the bolt switch (4) from the bolt switch stud (5).

Remove the cocking lever pin (7) and cocking lever (6).

Remove the accelerator stop lock (9) and accelerator stop (8).

Remove the sear slide (10). Press the sear (11) down with the thumb of one hand. With the thumb of the other hand, push the slide out sideways, square end first.

Remove the sear (11) and sear spring (12).

Remove the firing pin assembly (13) by tilting the front end of the bolt and shaking it.

Assembly—Bolt Group

Insert the firing pin assembly with notch downward.
Replace the sear and sear spring.
Replace the sear slide.
Insert the accelerator stop and stop lock.
Replace the cocking lever and cocking lever pin.
Replace the bolt switch.
Replace the extractor assembly.

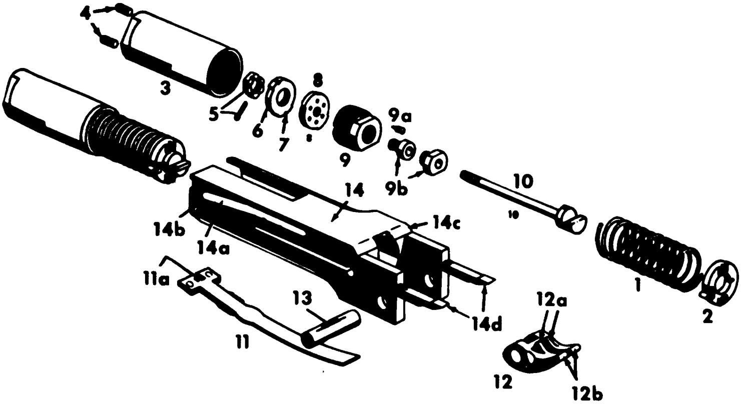


Figure 2–11.—Oil buffer group.

NOMENCLATURE FOR FIGURE 2–11

Oil Buffer Tubo Assembly

Nomenclature	Function
1. Oil buffer spring	Helps absorb the recoil of the barrel group and push it forward on counterrecoil.
2. Oil buffer spring guide and spring guide key.	The spring guide, which is prevented from turning by the spring guide key, holds the oil buffer spring in place.
3. Oil buffer tube	Houses the oil buffer parts.
4. Filler screws (two)	Provide openings for filling the oil buffer tube.
5. Piston head nut and pin	Holds the head and valve on the piston rod.
6. Piston valve	Closes and opens the holes in the piston rod head.
7. Valve keys (two)	Keeps the valve from turning.
8. Piston rod head	Pushes through the oil to absorb the recoil of the barrel group.
9. Tube cap	Closes the front of the oil buffer tube.
a. Relief valve assembly	Lets the oil escape if the pressure gets too great.
b. Packing gland assembly	Prevents oil leakage around the piston rod.
10. Piston rod and hook	Connects the barrel extension shank with the piston rod head.

Oil Buffer Body Assembly

Nomenclature	Function
11. Oil buffer tube lock	The front end bears against the bottom of the accelerator to hold it in the locked position until released by the bolt. The protrusion keeps the oil buffer tube from turning freely.
a. Protrusion	

NOMENCLATURE FOR FIGURE 2-11—Continued

Nomenclature	Function
12. Accelerator	Serves as an energy transmitter, a locking device, and a timing device.
a. Locking lugs	
b. Tips	
13. Accelerator pin	Holds the accelerator and provides it with a pivot.
14. Oil buffer body	Houses all parts of the oil buffer group.
a. Oil buffer body spring lock (if used).	Holds the oil buffer group in place in the receiver when the back plate is off.
b. Oil buffer body guides (two).	Fit into slots in the receiver, helping hold the oil buffer group in place.
c. Shoulders	Prevent the tips of the accelerator from turning too far down.
d. Breech lock depressors (two).	Force the breech lock down by camming down the breech lock pin.

Disassembly—Oil Buffer Group

Remove the oil buffer tube assembly.

Take off the tube lock (11).

Remove the accelerator (12) by drifting out the accelerator pin (13).

Assembly—Oil Buffer Group

Replace the tube lock.

Replace the accelerator and pin.

Replace the oil buffer tube assembly.

Adjust the oil buffer. (Details on adjusting the oil buffer are included under ADJUSTMENTS.)

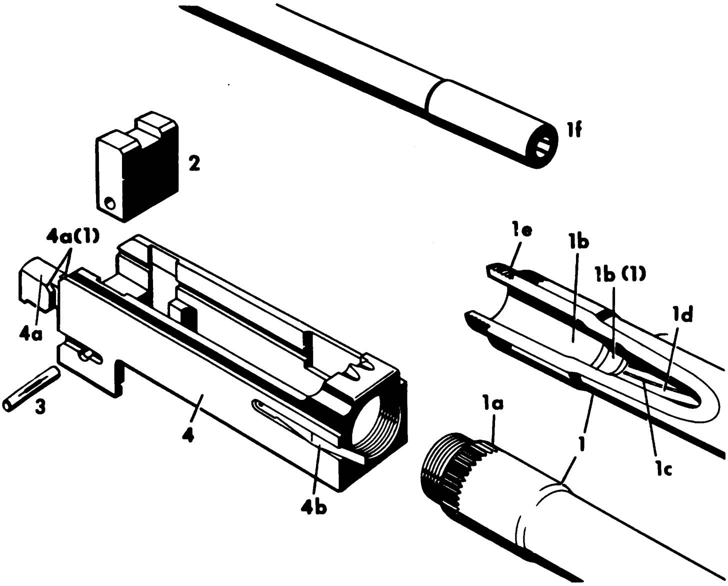


Figure 2–12.—Barrel and barrel extension group.

NOMENCLATURE FOR FIGURE 2–12

Nomenclature	Function
1. Barrel	Gives the bullet direction and spin.
a. Barrel locking notches	Fit against the barrel locking spring, keeping the barrel from turning freely.
b. Chamber	Houses the round while being fired.
(1) Shoulders of chamber.	Support the forward end of the cartridge case.
c. Lands d. Grooves } Rifling	Give the bullet its spin.
e. Breech end of barrel	
f. Muzzle end of barrel	
2. Breech lock	Locks the bolt to the barrel extension.
3. Breech lock pin	Holds the breech lock in the barrel extension; hits the depressors on the oil buffer body, forcing the breech lock down during recoil.
4. Barrel extension	Serves as a connection between the bolt, barrel, oil buffer, and receiver.
a. Barrel extension shank and hook.	Connects the barrel extension to the oil buffer tube assembly.

NOMENCLATURE FOR FIGURE 2-12—Continued

Nomenclature	Function
(1) Shank shoulders	Provide a surface for the accelerator to lock the barrel extension to the oil buffer body.
b. Barrel locking spring	Fits into the barrel locking notches, keeping the barrel from turning freely.

Disassembly—Barrel and Barrel Extension Group

Separate the barrel (1) and barrel extension (4) by unscrewing them.

Remove the breech lock (2) by drifting out the breech lock pin (3).

Assembly—Barrel and Barrel Extension Group

Replace the breech lock.

Screw the barrel into the barrel extension as far as it will go, then unscrew it about one-half turn.

Adjust for headspace as follows:

Put the bolt (with the extractor assembly and switch removed) on the barrel extension and slide it all the way forward. Hold the gun upside down, placing one hand near the breech end of the barrel and the other hand on the barrel extension, with the thumb holding the breech lock down firmly. Do NOT SUPPORT THE BARREL ON A BENCH. With one quick movement, screw the barrel in as far as it will go. Then carefully unscrew the barrel three notches (until you hear three clicks of the barrel locking spring). Turn the parts right side up and remove your thumb—the breech lock should fall of its own weight. The headspace adjustment should now be nearly enough correct to permit the recoiling parts to go fully into battery position when the gun is reassembled. NOTE: This method of headspace adjustment is only approximate and must be rechecked after the gun is fully assembled. The procedure and the purpose of the adjustment are fully described in the section titled ADJUSTMENTS, later in this chapter.

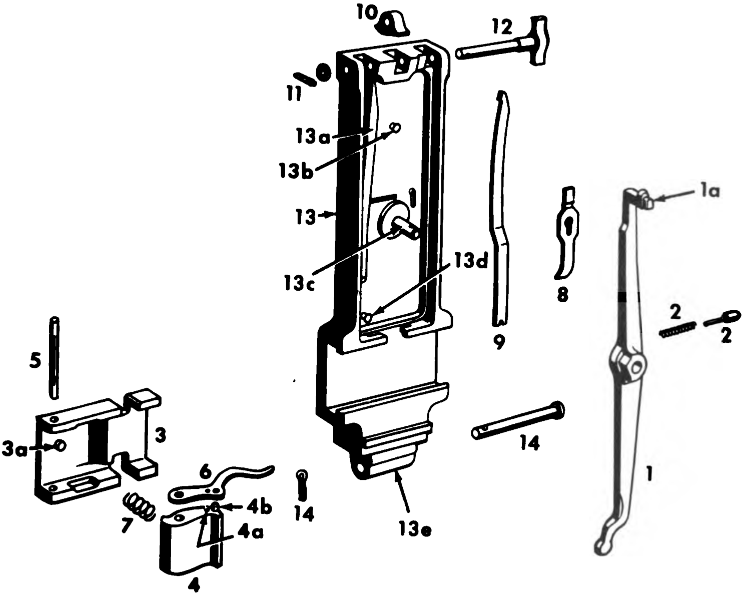


Figure 2–13.—Cover group.

NOMENCLATURE FOR FIGURE 2–13

Nomenclature	Function
1. Belt feed lever	Pivots from side to side to operate the feeding mechanism.
a. Belt feed lever lug	Rides in the bolt's cam grooves to move the lever from side to side.
2. Belt feed lever plunger and plunger spring.	Hold the belt feed lever in position when the cover is raised.
3. Belt feed slide	Moves outward from feedway and back to feed the ammunition belt into the gun.
a. Belt feed pawl spring stud.	Helps hold the pawl spring in place.
4. Belt feed pawl	Pushes the new round into the feedway.
a. Pawl arm locating pin	Hold the pawl arm in place.
b. Pawl arm pin	
5. Belt feed pawl pin	Holds the belt feed pawl and provides a pivot for it.
6. Belt feed pawl arm	Prevents double feeding.
7. Belt feed pawl spring	Pushes the belt feed pawl down behind the new round.
8. Cover latch spring	Presses against the cover latch keeping it locked.

NOMENCLATURE FOR FIGURE 2-13—Continued

Nomenclature	Function
9. Cover extractor spring	Holds the extractor assembly down while it is pulling a new round from the belt; cushions the shock when the extractor assembly is cammed up at the end of counterrecoil.
10. Cover latch	Holds the cover down.
11. Cotter pin and washer	Holds the cover latch shaft in the cover.
12. Cover latch shaft and lever	The shaft holds the cover latch. The lever serves as a handle to turn the shaft and unlock the latch.
13. Cover	Houses the parts of the cover group.
a. Cover extractor cam	Cams down the extractor assembly on recoil.
b Cover latch spring stud	Holds the cover latch spring in place.
c. Belt feed lever pivot stud and cotter pin.	The stud serves as a pivot for the belt and feed lever. The cotter pin holds the lever on the stud when the cover is closed.
d. Cover extractor spring stud.	Helps hold the cover extractor spring in place.
e. Detents	Grooves that work with the detent pawl (on the receiver) to hold the cover in any one of three positions when it is raised.
14. Cover pin and cotter pin	Fasten the cover to the receiver.

Disassembly—Cover Group

Remove the belt feed lever (1).

Remove the plunger and plunger spring (2) from the lever.

Remove the belt feed slide (3) by pulling it out the side.

Remove the belt feed pawl (4) from the slide. Hold the pawl down to keep its spring in place while drifting out the belt feed pawl pin (5).

Take the pawl arm (6) off the pawl and lift the belt feed pawl spring (7) off its stud.

Remove the cover latch spring (8). Pry out the bottom end of the cover latch spring and push it over on top of the cover extractor spring (9). Push the top end of the latch spring down until it lifts off its stud (13b).

Remove the cover extractor spring (9). Use one thumb to keep the spring from popping out. With the other hand, put a pointed tool into the notch in the side of the cover extractor cam (13a) and pry the spring out.

NOTE: Once removed from the receiver, the cover is often difficult to replace. For this reason, the cover should not be disassembled from the receiver unless necessary.

Assembly—Cover Group

Replace the cover extractor spring.

Replace the cover latch spring.

Hold the pawl with the side which bears against the belt toward you and its sharp end pointing in the direction of feed. Replace the belt feed pawl arm.

Replace the belt feed pawl in the slide.

Place the belt feed slide in the cover with the pawl arm on top.

Replace the plunger and plunger spring. (They go in the upper hole of the belt feed lever for left-hand feed, and in the lower hole for right-hand feed. The upper end of the belt feed lever can be recognized by the lug.)

Replace the belt feed lever. Insert the toe of the feed lever (the forward or lower end, depending on the position of the cover) through the slot in the front of the cover and engage the belt feed slide. At the same time, position the feed lever plunger and spring to clear the side of the cover and seat lever on the stud.

Insert a cotter pin through the stud.

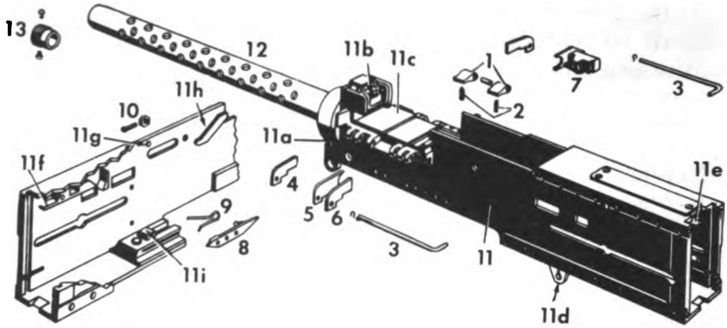


Figure 2–14.—Receiver and barrel jacket group.

NOMENCLATURE FOR FIGURE 2–14

Nomenclature	Function
1. Belt holding pawl	Holds the ammunition belt in the feedway.
2. Belt holding pawl springs	Exert upward pressure against pawl so it will assume a raised position behind a link of the ammunition belt.
3. Belt holding pawl pins	Hold the belt holding pawl and the cartridge stops.
4. Front cartridge stop	Holds the front of the cartridge in the correct position.
5. Link stripper	Holds the link steady as the cartridge is pulled from it and guides the empty link out of the feedway.
6. Rear cartridge stop	Holds the rear of the cartridge in the correct position.
7. Right-hand rear cartridge stop assembly.	Serves as a combination rear cartridge stop, link stripper, and short round eliminator when the gun feeds fom the left.
8. Extractor switch and switch pivot.	Cams the extractor assembly down at the beginning of counterrecoil to align the new round with the chamber.
9. Extractor switch spring	Returns switch to original position at end of recoil. This allows switch to cam extractor down at start of counterrecoil.
10. Extractor switch pivot nut and cotter pin.	Fasten the extractor switch to the receiver.
11. Receiver	Houses the working parts of the gun.
a. Trunnion adapter	Serves as a front mounting.
b. Detent pawl	Holds the cover up.
c. Trunnion block	Provides a bearing for the breech end of the barrel; forms the bottom of the feedway; serves as a spacer for the side plates.
d. Rear mounting holes	Serves as a rear mounting.

NOMENCLATURE FOR FIGURE 2–14—Continued

Nomenclature	Function
e. Rear trigger bar stop	Keeps rear end of trigger bar (if used) from going too high.
f. Top plate bracket	Holds trigger bar (if used).
(1) Front and rear cocking lever cams.	Cam the cocking lever backward and forward.
g. Bolt stop	Provides a means of locking the bolt to the rear.
h. Extractor cam	Cams the extractor assembly up on the last part of counterrecoil.
i. Breech lock cam	Cams the breech lock up on counterrecoil; prevents forward movement of the oil buffer body; supports the barrel extension by means of grooves on each side which engage the extension.
12. Barrel jacket	Houses the barrel and holds the front barrel bearing. Holes in jacket provide ventilation.
13. Front barrel bearing	Supports front end of the barrel and prevents whip.
14. Bunter plate	A hardened steel insert at the front of the feedway. It absorbs the impact of the bullet tip when the extractor engages the cartridge at the end of counterrecoil.

Disassembly—Receiver and Barrel Jacket Group

NOTE: Do not disassemble this group except for replacement of parts.

Remove the belt holding pawl (1) and springs (2). Keep the pawl pressed down with one hand while pulling out the belt holding pawl pin (3) with the other.

Take off the cartridge stops by pulling out the other belt holding pawl pin. On a gun feeding from the right, this will release the front cartridge stop (4), link stripper (5), and rear cartridge stop (6). On a gun feeding from the left, it will release the front cartridge stop (4) and the right-hand rear cartridge stop assembly (7).

Remove the extractor switch (8) and its spring (9). Take off the cotter pin and nut (10).

Assembly—Receiver and Barrel Jacket Group

Replace the extractor switch and its spring.

Replace the cartridge stops and insert the belt holding pawl pin that holds them. If the gun is to feed from the right, install the front and rear cartridge stops on the left, with the link stripper in between them. (The cartridge stops are stamped FRONT and REAR. The rear stop is always shorter.) If the gun is to feed from the left, install the front cartridge stop and right-hand rear cartridge stop assembly on the right.

Replace the belt holding pawl and springs on the right side for right feed, or left side or left feed. Seat the springs in the two holes and place the pawl on top. Press the pawl down with one hand while inserting the pin with the other.

ADJUSTMENTS

To keep the BAMG Cal. .50 operating with maximum efficiency, certain adjustments must be properly made and maintained. The gun must be adjusted for HEADSPACE and TIMING. The OIL BUFFER and the BUFFER ADJUSTING SCREW on the back plate must also be set properly. The purpose and method of these adjustments are described on the following pages.

Headspace

All firearms, regardless of type, have a measurement known as headspace. While there are more technical definitions of the term, it is simplest to think of headspace in Browning machine guns as THE DISTANCE BETWEEN THE FACE OF THE BOLT AND THE BREECH END OF THE BARREL when the recoiling parts are in battery and the bolt pulled back slightly to take up any slack at the breech lock—in other words, as it would be at the moment of firing.

This distance in the caliber .50 should be between 0.202 inch and 0.206 inch, and IS REGULATED BY THE DISTANCE THE BARREL IS SCREWED THROUGH THE BARREL EXTENSION. The headspace is measured with a GO—NO GO headspace gage. The GO end of the gage is 0.202 inch thick and the NO GO end is 0.206 inch thick. Even though the headspace must be accurate within thousandths of an inch, most experienced ordnancemen can accurately set it by "feel" alone. However, almost all of them then check themselves by using the headspace gage. The method of using the gage will be described later.

Results of Headspace Adjustment

EXCESSIVELY TIGHT HEADSPACE occurs when the breech end of the barrel projects so far back that the bolt's forward motion is stopped before its breech lock recess is directly over the breech lock. Thus the breech lock cannot move all the way up into the bolt and the bottom of the breech lock cannot ride up over the breech lock cam. This prevents the barrel extension from going completely into battery, and a space can be seen between the front of the barrel extension and the trunnion block or feedway. The bolt may be so far back the gun will not fire at all. At best, the gun will fire one round and stop, since the extractor assembly will not be able to reach the belt to pull out a new round.

TIGHT HEADSPACE occurs when the bolt goes forward barely enough to permit the breech lock to enter the recess. The front of the breech lock is held tightly against the front of the breech lock recess; gun operation will be sluggish and possibly after firing a few rounds a stoppage may occur. The gun will not be able to pull a long and heavy ammunition belt.

The GO end of the headspace gage cannot be inserted between the bolt and barrel, showing that headspace is too tight.

CORRECT HEADSPACE allows just a little play between the breech lock and the front of the breech lock recess. In effect, after firing, this gives the bolt a "running start" before it begins to move the barrel and extension to the rear and produces a smoother, more efficient operation. The round is firmly supported by the face of the bolt and the walls of the chamber.

LOOSE HEADSPACE allows too much play between the breech lock and breech lock recess. This results in considerable battering of these two parts and the breech lock cam as well, with a corresponding rapid wear of parts.

When the bolt is drawn back to take up this slack at the breech lock, the NO GO end of the headspace gage may be easily inserted between the bolt and breech end of the barrel, indicating the distance between the two is too great.

EXCESSIVELY LOOSE HEADSPACE occurs when the breech end of the barrel is not screwed completely through the barrel extension. As a result, there is too much space between the face of the bolt and the barrel, and the bolt is unable to hold the round firmly against the shoulder of the chamber. The following bad effects are the result:

1. The cartridge case, unsupported by the shoulder of the chamber, is frequently blown apart by the propellant charge. It may be separated into two sections, with the forward part left in the chamber when the rest of the case is extracted, or the case may be split lengthwise. A separated case is usually difficult to remove from the chamber.

2. Since the case is not seated properly in the chamber, an imperfect gas seal at the breech is the result, and the range and trajectory of the bullet is affected.

3. When the bolt goes forward into battery, it slams into the barrel extension. The **T**-slot is battered and often the barrel extension is broken about halfway back.

TO CHECK HEADSPACE WITH A GAGE:

For best results, the gun should be completely assembled before using a headspace gage. Cock the firing pin by charging the gun and letting the parts go fully into battery.

Draw the bolt back slightly (no more than 1/16 inch) to remove any slack between the breech lock and breech lock recess.

Check for tight headspace by inserting the GO end of the gage into the **T**-slot, between the face of the bolt and the breech end of the barrel. The gage may be inserted from either the top or bottom of the gun. If inserted from the bottom, the bolt can be drawn back by inserting a screwdriver in the **T**-slot and using it as a lever. This procedure may be necessary in some turret installations where it is impossible to fully open the cover.

If the GO end of the gage CANNOT be inserted, the headspace is too tight. To correct the adjustment, retract the bolt about one inch and unscrew the barrel one notch by applying a screwdriver to the locking notches. Return the bolt to battery, take up the slack, and check with the gage. Continue this procedure until the gage can be inserted.

If the GO end of the gage CAN be inserted, attempt to insert the NO GO end of the gage. If the NO GO end of the gage can be inserted, the headspace is too loose. Correct the adjustment by screwing the barrel into the barrel extension, one notch at a time, until the NO GO end of the gage cannot be inserted. (If the gun is set up for left-hand feed, remove the right-hand rear cartridge stop assembly for ease in screwing the barrel into the barrel extension.)

When the position is found where the GO end of the gage will enter the space between the face of the bolt and the breech end of the barrel, and the NO GO end of the gage will not enter, headspace is correct.

After correct headspace is obtained, release the firing pin. NEVER release the firing pin with the headspace gage in place as doing so will damage the firing pin.

Timing

The point at which the firing pin is released when the recoiling parts reach the battery position during counterrecoil is referred to as TIMING. This point is determined by measuring the distance between the front face of the barrel extension and the rear face of the trunnion block with a standard TIMING GAGE. The gun must fire when this distance is between 0.020 and 0.116 inch. Timing must be checked and adjusted each time headspace is checked and adjusted and at any other time when correctness is doubted.

If the gun is more than 0.116 inch out of battery when it fires, it is timed TOO EARLY. It will fire two rounds and stop, because the recoil from the second round starts before the extractor hook can reach the cartridge in the feedway.

If the gun is less than 0.020 inch out of battery when it fires, it is timed TOO LATE. The rate of fire is slowed down and the barrel extension batters the trunion block as the parts slam into battery position.

Timing of the gun is accomplished by making adjustments on the ELECTRIC TRIGGER CONTROL, sometimes referred to as the firing solenoid. The trigger control is either attached to the mounting flange which fits into slots in either side of the gun, or is mounted on a bracket attached to the buffer tube of the back plate, depending upon the type used. In either case, a movable plunger in a coil protrudes to operate the firing mechanism. When the solenoid is energized by pressing the firing switch, magnetic forces in the core of the solenoid coil attract the plunger, and operate the firing mechanism, thus firing the gun. Release of the firing switch opens the circuit and a spring returns the plunger to its original position, causing the gun to cease firing. A notched dial on the control may be turned to adjust the timing of the gun. Each notch on the dial moves the solenoid plunger 0.003 inch.

PROCEDURE IN TIMING THE GUN:

1. Adjust and check headspace.
2. Charge the gun.
3. Retract the bolt about 1/4 inch.
4. Insert the NO FIRE leaf of the timing gage between the barrel extension and the trunnion block.
5. Allow the barrel extension to close slowly until stopped by contacting the gage.
6. Attempt to release the firing pin, then follow procedure *a* or *b* below, whichever is applicable.
   - *a.* IF THE FIRING PIN FAILS TO RELEASE:
     - (1) Increase the solenoid dial one notch at a time until firing pin will release.
     - (2) Decrease solenoid dial five notches.
   - *b.* IF THE FIRING PIN DOES RELEASE:
     - (1) Decrease the solenoid dial one notch at a time until firing pin will not release.
     - (2) Decrease solenoid dial four more notches.

NOTE: Proof of firing or not firing is the release or attempt to release of the firing pin three times on the same dial setting.

Oil Buffer Adjustment

Proper adjustment of the oil buffer is important since the rate of fire of the gun is partially controlled by the oil buffer.

When the oil buffer tube is turned, the valve inside the tube also turns, because the valve key is held in a slot in the side of the tube. Turning the valve changes the size of the restricted openings. Increasing the size of the openings lets the piston push back through the oil more rapidly on recoil. Decreasing them slows up the piston.

The openings are largest, and the rate of fire is most rapid, when the SLOTS IN THE SIDE OF THE VALVE ARE IN LINE WITH THE SLOTS IN THE SIDE OF THE PISTON HEAD. This is the proper adjustment for all aircraft machine guns, regardless of temperature and altitude, in all cases where the buffer tube has been filled with the correct oil.

If the restricted openings are too small, the rate of fire will be too slow. The gun's action may stop part of the way back on recoil.

Because of differences in the manufacture of machine guns, the openings are not necessarily at their widest when the arrow on the buffer tube points to the O (for open). The only way to be sure the adjustment is correct is to see that the tube lock protrusion is in the third notch from the left at the bottom of the tube.

To make this adjustment, turn the oil buffer tube counterclockwise until the clicking stops, then turn it clockwise until three clicks are heard. In this position the oil buffer is adjusted for maximum rate of fire.

Buffer Adjusting Screw Adjustment

Tightening the buffer adjusting screw increases the pressure on the buffer disks; loosening the screw decreases the pressure.

There are usually 22 disks in the tube. If they are too worn, or if there are too few of them, the adjusting screw will go in too far. If there are too many disks, or if they are not seated properly, the screw will not go in far enough.

If the screw is too tight, or if the disks are too worn, they are unable to cushion the shock of the recoiling bolt. The pounding of the bolt may strip the threads off the adjusting screw and drive it out the rear of the buffer tube or shear off the sides of the back plate and force it off the back of the receiver.

If the adjusting screw is too loose, or if there are too few disks, the bolt will batter against the back plate instead of the buffer plate, and may break the back plate and drive it off the receiver.

To make this adjustment, tighten the buffer adjustment screw as tight as possible, using a caliber .50 combination wrench. Remove the back plate and press on the buffer plate to make sure it is held firmly in position.

The adjustment is correct when the end of the screw does not go inside the tube, nor extend out more than one thread.

Changing Direction of Feed

In order to change the gun from left-hand feed to right-hand feed, or vice versa, repositioning of parts must be made in the bolt group, cover group, and in certain parts in the receiver. The correct position of the various parts for both left-hand and right-hand feed is shown in figure 2–15. The change from left-hand feed to right-hand feed is described below; by reversing the process, the gun may be changed from right-hand feed to left-hand feed.

Bolt group.—1. Remove the bolt group from the gun.

2. Remove the extractor assembly from the bolt.

3. Lift the bolt switch high enough to clear the bolt switch stud and rotate it one-half turn so that the bolt switch stud enters the opposite hole in the bolt switch. The cam groove in the bolt switch will then line up to make the groove in the bolt marked R (right) continuous. In this position the wide part of the switch will be toward the rear of the bolt.

4. Assemble the extractor assembly to the bolt and replace the bolt group in the receiver.

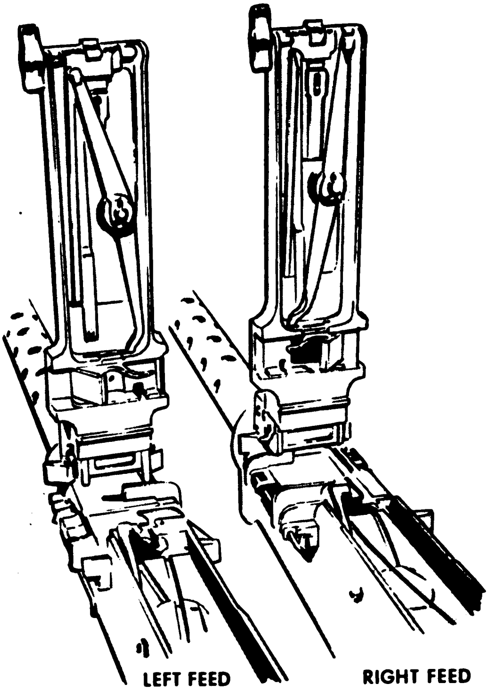


Figure 2–15.—Changing direction of feed.

COVER GROUP.—1. Open the cover and remove the belt feed lever. Transfer the belt feed lever plunger and spring from the upper hole in the belt feed lever to the lower hole. Do not replace the lever in the cover.

2. Remove the assembled belt feed slide from the cover. Push out the belt feed pawl pin and remove the feed pawl and feed pawl arm and spring from the slide. Take care not to lose the spring.

3. Change the belt feed pawl arm from one side of the feed pawl to the other, so that when replaced in the belt feed slide it will be to the rear when the cover is closed (or at the top of the feed pawl when the cover is raised). The locating pins on the feed pawl will locate the arm in the proper position.

4. Reassemble the belt feed pawl, arm, and spring to the belt feed slide and insert the belt feed pawl pin. Place the assembled slide in the cover with the pawl end of the slide pointing in the direction of feed.

5. Position the belt feed slide so that the gap in the slide is in line with the cutout in the cover and replace the belt feed lever. Install the feed lever cotter pin.

RECEIVER GROUP (FEEDWAY).—1. Remove the two belt holding pawl pins.

2. Change the front cartridge stop from the right side of the feedway to the left. Remove the right-hand rear cartridge stop assembly and retain it for use when left-hand feed is again desired. A rear cartridge stop and a link stripper (supplied as auxiliary parts with each gun) should be broken out of spare parts and placed in their grooves on the left-hand side of the feedway.

3. Transfer the belt holding pawls and springs from the left side of the feedway to the right.

4. Reinstall the two belt holding pawl pins.

Clearances and Adjustments

Correct length of oil buffer tube	6.525 to 6.553 inches.
Correct headspace	0.202 to 0.206 inch.
GO end of headspace gage	0.202 inch.
NO GO end of headspace gage	0.206 inch.
FIRE leaf of timing gage	0.020 inch.
NO FIRE leaf of timing gage	0.116 inch.
Clearance of breech lock cam and bottom plate of receiver	0.001 to 0.012 inch.

Clearance between piston valve and piston rod head	0.045 to 0.055 inch.
Minimum length of driving springs	21 inches.
Maximum length of cartridges	5.45 inches.

Malfunction Analysis

A malfunction is the improper or incomplete operation of some part of the gun or its ammunition, which usually causes the gun to cease firing. Such a cessation of fire is called a stoppage.

Stoppages which can be corrected by immediate action are called TEMPORARY while PROLONGED stoppages require the repair or replacement of a part or parts.

Stoppages may be further classified by the position of the bolt when the stoppage occurred:

First position—Bolt is in full battery position.

Second position—Bolt is any place between all the way forward and halfway back.

Third position—Bolt is any place between halfway back and all the way back.

When trouble develops, the accessory equipment should be carefully checked before assuming that the gun itself is responsible for the stoppage. After checking the accessories, check the ammunition and links feeding into the gun. In this manner it can be determined if the stoppage is caused by misalignment due to improper loading of cartridges in the belt, to short rounds, to a link caught in the link stripper or to other causes.

Some of the most common malfunctions are listed in the following paragraphs.

GUN STOPS FIRING IN BATTERY POSITION WITH LIVE CARTRIDGE IN CHAMBER.—This condition is probably caused by one of the following:

1. Firing pin extension binding in its tunnel in bolt.
2. Firing pin spring weak or broken.
3. Excess oil or foreign matter in firing pin spring.
4. Defective ammunition.
5. Firing pin point eroded or broken.
6. Sear notch worn.
7. Sear spring weak.
8. Cocking lever broken or worn.

GUN STOPS FIRING IN BATTERY POSITION WITH NO CARTRIDGE

IN CHAMBER.—This condition is probably caused by one of the following:

1. Belt feed lever bent or broken.
2. Long ammunition belt imposes too heavy feeding load.
3. Belt holding pawl springs weak or broken.
4. Extractor bent, broken, or deformed.
5. Short rounds.
6. Defective belt feed slide assembly.
7. Defective belt links.

GUN STOPS FIRING WITH BOLT OUT OF BATTERY POSITION.—This condition may be caused by any of the following:

1. Driving springs weak or broken.
2. Adjusting screw in back plate loose, or buffer disks defective.
3. Oil buffer short.
4. Headspace too tight.
5. Bolt binds between side plates.
6. Belt link catches in link stripper.
7. Bolt stud binding in slot of side plate.
8. Breech lock cam too tight.
9. Firing pin hole enlarged or recoil plate not flush with face of bolt.
10. Ruptured cartridge case in chamber.

GUN PERSISTENTLY FIRES ONE ROUND AND STOPS.—Probable cause:

1. Oil buffer set in closed position. (When the oil buffer is set in the closed position there is insufficient recoil to complete the feeding, extracting, and ejecting operations; therefore, the gun stops with the parts out of battery position after the cartridge which was charged into the chamber is fired.)

GUN FIRES TWO ROUNDS AND STOPS IN BATTERY POSITION, WITH NO CARTRIDGE IN THE CHAMBER.—Probable cause:

1. Early timing.

MAINTENANCE

Cleaning

Thorough cleaning of the gun is extremely important and should be accomplished as soon after firing as is possible. When a gun is fired, the gas pressure forces a deposit of primer salts into the pores of the metal parts of the chamber and bore, on the face of the bolt, and on all other parts adjacent to the chamber. Primer salts are extremely corrosive, and if not properly removed, will result in sufficient pitting and corrosion to cause malfunctions and shorten the life of the parts so affected.

The best cleaning agent for the bore of the barrel is rifle bore cleaner. If rifle bore cleaner is not available, hot water and soap or plain hot water may be used. Rifle bore cleaner contains water, therefore, all traces of the cleaner must be removed by swabbing the bore with clean, dry patches until it is perfectly dry and clean.

Caution: Never use oil to clean the bore until one of the above solutions has been used. Oil will cover the corrosive primer salt particles, but will not remove them; the salts continue to absorb moisture even when covered with oil.

Clean other parts of the gun with rifle bore cleaner or dry-cleaning solvent. Thoroughly clean every part, removing all dirt, moisture, and primer salts. After the parts have been cleaned, dry them with a clean, lintless rag.

Do not touch parts with the bare hands after cleaning until they have been oiled. Fingerprints contain an acid which causes corrosion. If cloth gloves are available, wear them while oiling the gun. If gloves are not available, keep the hands covered with oil while handling the parts.

Lubrication

Lubricating oil reduces the friction between sliding surfaces and protects metal parts against corrosion. Guns require oil for satisfactory operation at all temperatures. Use of the correct grade of lubricating oil, properly applied, cannot be overemphasized to insure satisfactory gun performance.

Oil Lubricating Preservative Special, Specification JAN–L–644 is the only oil recommended for the lubrication of aircraft guns. It is used in the undiluted form.

Apply lubricating oil to the gun parts by wiping them with a clean, lint-free cloth that has been saturated with oil and then wrung out as dry as possible. It is extremely important that the oil be applied sparingly and that only a thin film of oil remains on any working part. Excess oil in the barrel chamber may raise the breech pressure to a hazardous degree. Before firing, wipe the bore and chamber of the barrel completely dry of oil.

Points to be lubricated.—In addition to the general lubrication of the gun, special attention should be given the following points:

- Belt feed lever grooves in the bolt.
- Belt feed lever pivot stud.
- Bore and chamber.
- Breech lock.
- Extractor pivot.
- Guideways in the barrel extension for the bolt guides.
- Oil buffer.
- Breech lock cam guides and top.
- Cocking lever.
- Cover extractor cam.
- Cover extractor spring.
- Sear, sear slide, and the grooves in which they operate.
- Slideway in cover for the belt feed slide.
- Switch pivot.

Filling the oil buffer.—Remove both filler screws. Use a small oil can filled with oil, Specification JAN–L–644. To avoid getting air bubbles in the buffer tube, turn the oil can upside down and press the bottom to start the oil flowing before inserting the nozzle in one of the openings. Remove the nozzle before releasing the bottom of the can, then press it again to start the oil flowing and reinsert the nozzle in the tube. Repeat the operation until the oil buffer overflows. Replace the filler screws.

Repair

Repair of the gun is largely a matter of replacing worn or broken parts. In addition, a certain amount of polishing and stoning of working surfaces is necessary during the entire working life of the gun to relieve friction and to remove burrs set up by firing. Burrs on screw heads, threads, and the like may be removed with a fine file. On working surfaces such as the cam grooves on top of the bolt, the engaging surfaces of the sear slide, the sear, and firing pin extension; and on such parts as the accelerator and breechblock, burrs should be removed with a fine-grain sharpening stone. Rounded contacting surfaces may be smoothed and polished with crocus cloth.

SAFETY PRECAUTIONS

In the Shop

Before starting to work on a gun make sure it is securely anchored in the mounting. Never lay a gun down where it may fall.

Make sure that the chamber of the barrel and the **T**-slot of the bolt are free from cartridges.

Never cock the gun against the pressure of the driving springs with the back plate removed from the gun.

Never alter or force any part when stripping or assembling the gun.

Always make sure that the gun has been checked and adjusted for proper headspace.

Be sure that the cocking lever always points forward when the bolt is placed in the receiver.

While Firing

Before loading the gun, make sure that the bore of the barrel is clear and dry. Chamber and bore must be free of oil.

Before loading with live rounds, always test operation by hand, using dummy cartridges.

Always make sure that the cover is securely latched.

Be sure that the back plate is properly in place and that the latch and latch lock are engaged.

On a hangfire or misfire always wait 10 to 15 seconds before raising the cover.

If an overheating burst is fired, clear the gun within 10 seconds after completion of the burst. If the gun cannot be cleared within 10 seconds, allow the round to remain in the chamber a minimum of 5 minutes, making sure that the gun is aimed away from personnel and equipment. IF AN ATTEMPT IS MADE TO CLEAR THE GUN BETWEEN THE 10-SECOND AND THE 5-MINUTE PERIOD, THE EXTRACTED CARTRIDGE MAY EXPLODE OUTSIDE THE WEAPON. NOTE: The maximum single burst which may be fired without danger of cook-off is 150 rounds.

It occasionally happens that a gun commences firing as soon as a round is chambered or continues firing after the trigger has been released. This uncontrolled firing is known as a "runaway gun." Uncontrolled automatic fire is almost always the result of a broken part, such as a sear or firing pin, and while it is possible for an extremely hot barrel to cook-off several rounds rapidly in succession, the firing of these rounds would be at a much lower rate than normal automatic fire.

Regardless of cause, a runaway gun is extremely dangerous and must be stopped as soon as possible. If it is unlikely that the firing is caused by cooking-off, either raise the cover to prevent further feeding or charge the gun to hold the bolt out of battery. If a hydraulic charger is used, set it in the SAFE position to hold the bolt back; if manual charging is used, hold the bolt to the rear by hand until the cover is opened or feeding otherwise prevented.

If the cover is inaccessible or it is known the firing is caused by cooking-off, grasp and hold (or twist) the ammunition belt to prevent further feeding. If this method is used, fully unload the gun after a 5-minute wait, carefully inspect the feed lever, feed and holding pawls, and other feed parts for possible damage.

BORESIGHTING

Introduction

In order to obtain accuracy of fire in gun installations it is necessary that a definite relationship be established between the line of sight and the line of fire. When the sight is located near the gun, as in some turret installations, the line of sight and line of fire are practically parallel. In gun installations where the gun is located at a distance from the sight, as in all forward-firing (fixed) guns, the line of fire usually intersects the line of sight. In either case, the necessary operations required in establishing the correct relationship between the line of sight and the line of fire is called BORESIGHTING.

Boresighting Terms and Definitions

Familiarity with the following boresighting terms and definitions is necessary for a complete understanding of the theory of boresighting.

LINE OF FIRE.—A line extending through the center of the gun bore and projected out into space.

LINE OF SIGHT.—A line from the gunner's eye extending through the center aiming point of the sight and projected out into space.

LINE OF FLIGHT.—The flight path of the airplane.

PARALLEL BORESIGHTING.—Alignment of a gun and its sight so that the line of fire and the line of sight are parallel.

CONVERGENT BORESIGHTING.—Alignment of a gun and its sight so that the line of fire and the line of sight converge (intersect) at a predetermined range or distance from the gun.

Point of convergence.—The distance from the gun where the line of fire and line of sight converge or intersect.

Long range boresighting.—A method of boresighting in which a distant object is used as a target, usually located at the point of convergence.

Screen boresighting.—A method of boresighting at short range, using a specially prepared template or screen as a target.

Boresighting templet (or screen).—A specially prepared card or screen used as the target in screen boresighting.

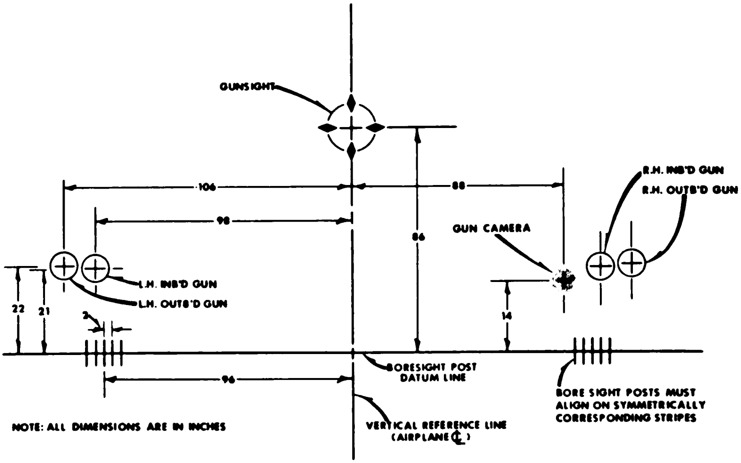

GUNSIGHT
106
88
98
86
GUN CAMERA
R.H. INB'D GUN
R.H. OUTB'D GUN
L.H. INB'D GUN
L.H. OUTB'D GUN
22
21
2
14
96
BORESIGHT POST DATUM LINE
BORE SIGHT POSTS MUST ALIGN ON SYMMETRICALLY CORRESPONDING STRIPES
NOTE: ALL DIMENSIONS ARE IN INCHES
VERTICAL REFERENCE LINE (AIRPLANE ℄)

Figure 2–16.—Boresight chart.

Boresight chart.—A diagram or chart showing all the measurements and other information necessary for the construction of a boresight template or screen. (See fig. 2–16.) Boresight charts are supplied by the airplane manufacturers and are available in the *Erection and Maintenance Manuals.* (Maintenance Instructions.)

Boresight posts.—Attachments which may be fitted in the wing panels (or fuselage of some airplanes), resembling the sights on a rifle, and used in aligning the boresight screen

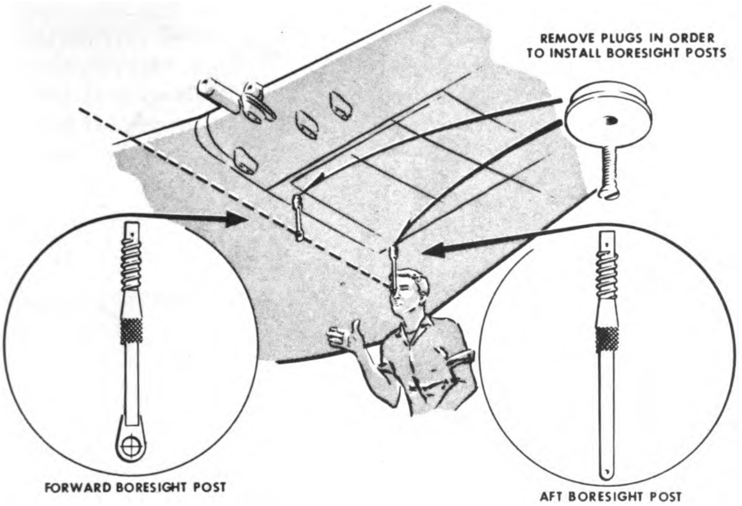


Figure 2–17.—Installation and use of boresight posts.

or template and the airplane when boresighting forward-firing guns. (See fig. 2–17.)

Boresight kit.—A kit containing optical extensions that can be inserted into the breeches or muzzles of guns mounted in inaccessible places. By sighting through the eyepiece of the sighting extension, the ordnanceman can align the gun bore with the target just as though he were looking through the gun bore. (See fig. 2–18.)

Boresighting Procedure

As a general rule the guns and sight of any installation must be boresighted after any one of the following operations: installation of the gunsight, temporary removal or replacement of the complete sighting head, or installation or replacement of a gun or guns. Boresighting may also be required on certain routine inspections, such as the 120-hour or other routine inspection.

Screen Boresighting

As previously defined, screen boresighting is a method of boresighting at close range, using a specially prepared tem-

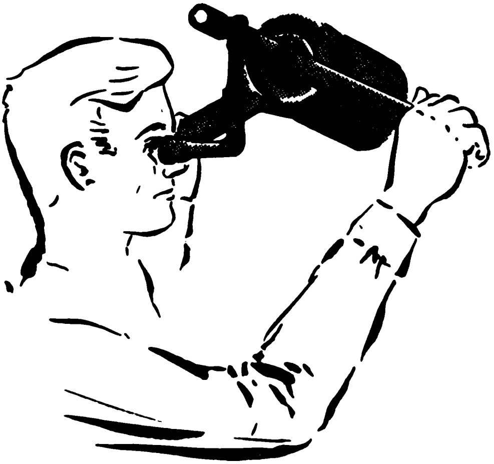


Figure 2–18.—Use of boresight eyepiece.

plate or screen as a target. Once a template or screen has been made, it can be used over and over for all the airplanes of the same model.

Screen boresighting has two distinct advantages: (1) it can be performed in a small area where a limited space is available, and (2) it is the most accurate method of boresighting when performed strictly according to instructions in the *Maintenance Manual*. NOTE: Accuracy is of utmost importance in screen boresighting since any error at the screen will be magnified several times at the point of convergence.

FIXED GUNS.—In addition to the LINE OF SIGHT and the LINE OF FIRE, the LINE OF FLIGHT of the airplane is an important factor to be considered in boresighting fixed guns. The correct relationship between the line of sight, the line of fire, and the line of flight is easily established in screen boresighting, and is therefore recommended for all fixed gun installations.

The general procedure in screen boresighting follows:

First, the airplane is roughly lined up in flying attitude and at the proper distance from the templet or screen. Exact airplane-to-screen alignment is then accomplished by sighting onto the screen through the boresight posts (see fig. 2–19) and adjusting the screen accordingly. (Exact airplane-to-screen alignment is necessary to assure the correct relationship between the line of sight and the line of flight of the airplane.) After the screen has been properly aligned in relation to the airplane, the guns and sight are then adjusted in alignment with their respective target spots on the screen.

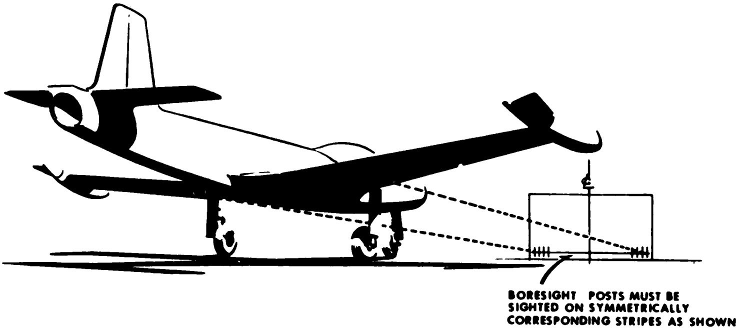

℄
BORESIGHT POSTS MUST BE SIGHTED ON SYMMETRICALLY CORRESPONDING STRIPES AS SHOWN

Figure 2–19.—Boresight posts proporly sighted on targets.

The following is a step by step procedure for boresighting the fixed guns on a typical fighter type airplane.

1. Place the boresight screen the proper distance from the airplane, with the airplane in the approximate level flight attitude.
2. Remove the plugs from the two boresight post receptacle holes in each wing.
3. Insert front and rear posts into forward and aft holes as far as they will go, rotating each so that the cross hairs on the forward post and the peephole on the aft post are facing the screen.
4. Sight through both sets of posts and shift the screen (or airplane) until the screen is in proper alignment with the boresight posts.
5. Remove the fairing and clamps from the front mount of the first gun to be boresighted.
6. Break the lock wire and loosen the two cap screws on the front mount assembly.
7. Insert the eyepiece and muzzle adapter (from Mk 1 boresight kit) into the muzzle of gun.
8. Using the special wrenches provided, and sighting

through the eyepiece, turn the front mount eccentrics until the desired target spot on the screen is obtained.

9. Secure front mount assembly by tightening cap screws, recheck gun alignment, then install safety wire.

10. Repeat steps 5, 6, 7, 8, and 9 for each gun to be boresighted.

11. Loosen the gunsight mounting clamp locking bolt. (This permits the sight to be rotated in any direction.)

12. Rotate the sight until the fixed cross image lines up with the gunsight target spot on the screen.

13. Tighten the mounting clamp locking bolt, making sure that in tightening, the fixed cross does not deviate from the target spot on the screen.

Long Range Boresighting

Long range boresighting is used principally in boresighting turret guns. In this method of boresighting, a distant object such as a standpipe, water tower, or corner of a building is used as a target. The object selected should be at the approximate distance from the gun where the line of fire and the line of sight are to converge. The gun and sight are then both aligned on the same spot on the target.

QUIZ

1. The operation of the caliber .50 is accomplished by
   - a. gas
   - b. blowback
   - c. recoil
   - d. manual operation

2. In changing feed the three groups that are involved are
   - a. cover, oil buffer, barrel extension
   - b. bolt, cover, oil buffer
   - c. receiver, bolt, back plate
   - d. bolt, cover, receiver

3. The two recoiling groups of this gun are
   - a. bolt, oil buffer
   - b. barrel and barrel extension; bolt
   - c. oil buffer, bolt
   - d. retracting slide, bolt

4. The maximum range of this weapon is
   - a. 7,200 yds.
   - b. 5,645 yds.
   - c. 6,375 yds.
   - d. 8,200 yds.

5. The empty case is extracted from the chamber by
   - a. T-slot
   - b. extractor
   - c. ejector
   - d. blowback

6. The bolt and barrel extension are locked together by
   - a. breech lock
   - b. oil buffer
   - c. breech lock depressors
   - d. tube lock assembly

7. What positively insures the unlocking of the bolt from the barrel extension?
   - a. Accelerator stop
   - b. Accelerator
   - c. Breech lock depressors
   - d. Breech lock cam

8. The new round is pulled into the gun by
   - a. belt feed pawl
   - b. belt feed pawl arm
   - c. extractor cam
   - d. cover extractor spring

9. The bolt, barrel, and barrel extension recoil together for
    a. ⅞ inch
    b. 9/64 inch
    c. 5/16 inch
    d. ¾ inch

10. The recoil of the barrel and barrel extension is absorbed by
    a. back plate
    b. bolt
    c. oil buffer
    d. breech lock cam

11. The barrel and barrel extension is locked to the rear by
    a. extractor switch
    b. compressed oil buffer spring
    c. bolt stud
    d. accelerator

12. The firing pin spring is compressed between the
    a. firing pin spring stop pin and the accelerator stop pin
    b. firing pin spring stop pin and the sear
    c. sear spring and the T-slot
    d. bolt switch and the accelerator stop pin

13. The cocking lever rides in and is actuated by the
    a. top plate bracket
    b. T-slot
    c. rear of the back plate
    d. trigger bar

14. What drives the barrel and barrel extension forward on counterrecoil?
    a. The compressed driving spring
    b. The fiber disks in back plate
    c. The compressed oil buffer spring
    d. The barrel locking spring

15. On counterrecoil the extractor is forced upward to engage a new round by
    a. cover extractor spring
    b. cover extractor cam
    c. ejector
    d. extractor cam on side plate

16. The recoil plate is located on the
    a. breech lock cam
    b. face of the bolt
    c. back plate
    d. rear end of the barrel extension

17. To fill the oil buffer tube remove the
    a. valve keys
    b. Piston rod head
    c. tube cap
    d. two filler screws

18. The barrel extension is joined to the oil buffer by the
    a. barrel extension shank
    b. barrel locking spring
    c. breech lock depressors
    d. piston rod valve

19. Two of the most important adjustments to be made on this gun are
    a. oil buffer and headspace adjustments
    b. headspace and timing adjustments
    c. piston rod head and piston valve adjustments
    d. breech lock cam and bottom plate receiver clearance adjustments

20. The correct timing clearance is
    a. 0.016 inch
    b. 0.202 inch—0.206 inch
    c. 0.020 inch—0.116 inch
    d. 0.003 inch

21. The correct headspace distance between the face of the bolt and the rear end of the barrel will be
    a. 0.202 inch—0.206 inch
    b. 0.016 inch
    c. 0.116 inch
    d. 0.012 inch

22. To insure that the extractor will engage a new round, tension is applied by the
    a. extractor cam
    b. cover latch spring
    c. belt feed pawl spring
    d. cover extractor spring

23. The ammunition belt is held into the feedway by the
    a. front cartridge stop
    b. belt holding pawl
    c. link stripper
    d. belt feed slide assembly

24. Each notch on the dial of the trigger control moves the solenoid plunger
    a. 0.101 inch
    b. 0.003 inch
    c. 0.008 inch
    d. 0.116 inch

25. The correct setting for the oil buffer to maintain maximum rate of fire is
    a. 3 clicks clockwise
    b. 3 clicks counterclockwise
    c. 10 clicks towards closed
    d. all the way open

26. When the oil buffer is in the closed position the gun
    a. will fire one round and stop out of battery
    b. will fire two rounds and stop in battery
    c. will keep firing slowly
    d. won't fire at all

27. What will cause the gun to fire one round and stop in battery without a round in chamber?
    a. Headspace adjusted wrong
    b. Defective belt feed slide assembly
    c. Reversed bolt switch
    d. Worn ejector

28. If the gun fires two rounds and stops in battery position with no round in chamber, the probable cause is
    a. worn extractor claw
    b. loose headspace
    c. oil buffer short
    d. early timing

29. The cause of a ruptured cartridge case is
    a. tight headspace
    b. short oil buffer
    c. early timing
    d. loose headspace

30. The trigger control (firing solenoid) may be mounted on
    a. either side of the gun
    b. right-hand side
    c. left-hand side
    d. rear only

31. Timing must be adjusted
    a. every twenty-four days
    b. after headspace is adjusted
    c. before headspace is adjusted
    d. after gunnery hops only

32. The clearance between the piston valve and the piston rod head in the oil buffer is
    a. 0.020 inch
    b. 0.525 inch
    c. 0.101 inch—0.116 inch
    d. 0.045 inch—0.055 inch

33. The extractor stop pin is located on the
    a. right rear side of the bolt
    b. right front side of the bolt
    c. left front side of the bolt
    d. left rear side of the bolt

34. The function of the ejector is to
    a. eject all the rounds from the gun
    b. withdraw the spent case from chamber
    c. eject the last round fired
    d. provide a stop for the extractor

35. The bolt stud must be mounted
    a. on the same side as the charger
    b. on the left-hand side only
    c. on the right-hand side only
    d. none of the above

36. The function of the accelerator is to
    a. lock the bolt forward
    b. unlock the oil buffer on recoil
    c. speed up the rearward travel of the bolt and lock the barrel extension to the rear
    d. speed up the forward movement of the bolt

37. The shock of the bolt's recoil is absorbed by the
    a. buffer disk in the back plate
    b. oil buffer spring
    c. barrel extension shank
    d. adjusting screw

38. The GO end of the headspace gage has a thickness of
    a. 0.020 inch
    b. 0.003 inch
    c. 0.202 inch
    d. 0.206 inch

39. The clearance between the breech lock cam and the bottom plate of the receiver is
    a. 0.001 inch—0.012 inch
    b. 0.202 inch—0.206 inch
    c. 0.003 inch
    d. 0.020 inch

40. When the gun stops firing, the first thing to look at is the position of the
    a. charger
    b. chamber
    c. bolt
    d. oil buffer

CHAPTER 3

20-MM AIRCRAFT GUNS

HISTORY AND DEVELOPMENT OF 20-MM GUNS

World War I was well along before anyone visualized the fighting power of an airplane equipped with automatic guns. During the first part of this period, airplanes were used only for observation purposes, and were unarmed. The only protection the pilot or observer had was his sidearm.

Rifles were later carried and fired by the observer, who stood erect in the cockpit. This was so difficult that it was not long until mounted automatic weapons were being used in combat. These early guns were adaptations of automatic ground weapons, speeded up in rate of fire and fitted with recoil mechanisms to assist in absorbing shock.

The Lewis Machine Gun caliber .30 was the first automatic weapon to be used in combat aircraft. Still later, the Browning Machine Gun caliber .30 made its appearance, followed a little later by the caliber .50 Browning.

In the meantime, the French Hispano-Suiza 20-mm Automatic Gun made its appearance. Our Armed Forces began intensive development of a 20-mm aircraft gun about 1937, and a short time later, purchased the Hispano-Suiza design from the French. The 20-mm gun was selected as the ideal size aircraft weapon because it was light and compact enough to be mounted in fighter-type aircraft, yet it was large enough to fire a high explosive projectile.

Our first model was designated the M1, but before it was ever used, several changes were made, and it became the M2. The M2 was installed in the SB2C in 1943, and saw extensive service during the remainder of World War II, but it had already been decided that a faster firing gun was necessary to compensate for the speedier aircraft that the enemy was producing. This led to the development of the M3, a weapon

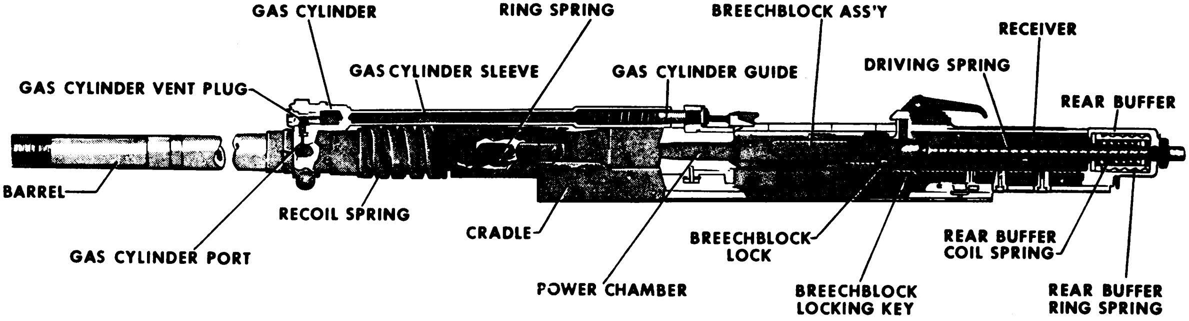


Figure 3–1.—20-mm Aircraft Automatic Gun M3.

which came into wide use in 1945, and is still being used in many Navy aircraft.

In 1948, when jet aircraft came into use, the Armed Forces realized that a weapon with a higher muzzle velocity and faster rate of fire was necessary. A more effective means of timing gunfire was also desired.

With the above ideas in mind, several new weapons were developed, including the M24, Mk 12, Mk 16, and Mk 17. Of this group of new weapons, only the Mk 12 is currently used by the Navy, although all have been tested in Navy aircraft.

20-MM GUN M3

General Description

The 20-mm Aircraft Automatic Gun M3 is a combination gas- and blowback-operated weapon capable of firing 650 to 800 rounds per minute. It is used in both fixed and turret installations and has an effective range of approximately 2,000 yards.

The operation of the gun can best be grasped by first un-

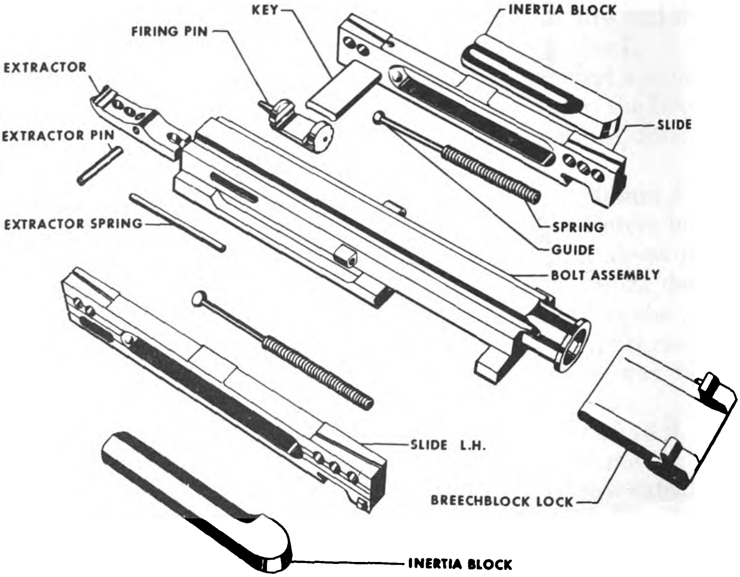


Figure 3–2.—Breechblock assembly components.

derstanding the construction of the breechblock assembly. Figure 3–2 shows the main components of the assembly. The entire assembly moves back and forth within the receiver.

The key to the action of the various parts lies in the action of the breechblock lock, which is seen at the right of the assembly in figure 3–2. (In figure 3–1, the lock is shown in its locked position.) The lock is activated by the breechblock slides (fig. 3–2), which are keyed together through a slot at the forward part of the bolt assembly. Cam surfaces are cut into the rear undersides of the slides. The relative positions of the breechblock lock, breechblock slides, breechblock key, and breechblock just after the gun has been fired are shown in detail in figure 3–3.

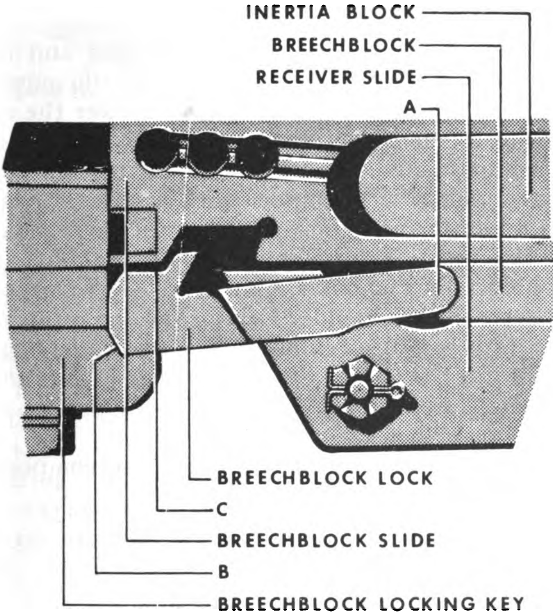


Figure 3–3.—Gun mechanism shortly after firing.

At its forward part (at point A), the lock butts against the rear surface of the breechblock (the surfaces are curved to fit each other). At its rear part (at point B), the lock butts against the breechblock locking key, which is fixed to the receiver. At its upper rear part (at point C), the lock is held down by the breechblock slides. It is easy to see that the lock cannot move upward to unlock, and thus the breechblock cannot move rearward, until the slides have released the lock.

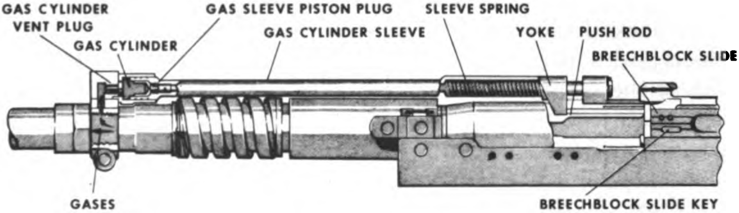


Figure 3–4.—Action of gas cylinder group for unlocking breech.

To see how the slides are moved rearward and the lock unlocked, refer to figure 3–4. As the projectile moves down the barrel, the expanding gases behind it enter the cylinder port leading to the gas cylinder. The gases force the gas cylinder piston to the rear. The yoke at the aft end of the gas cylinder piston is in contact with a pair of push rods, which in turn are in contact with the forward ends of the breechblock slides. The pressure of the breechblock against the breechblock lock at point A in figure 3–3 forces the lock to unseat from the breechblock locking key and rotate upward as soon as the breechblock slides have moved far enough rearward to uncover the lock. The breechblock is thus unlocked, and blowback forces it to the rear. The complete cycle of operation is described later.

The M3 gun consists of the following ten components or assemblies:

Cradle
Gun barrel
Recoil mechanism
Receiver
Breechblock
Sear mechanism
Magazine slide assembly
Rear buffer
Driving spring guide assembly
Gas mechanism

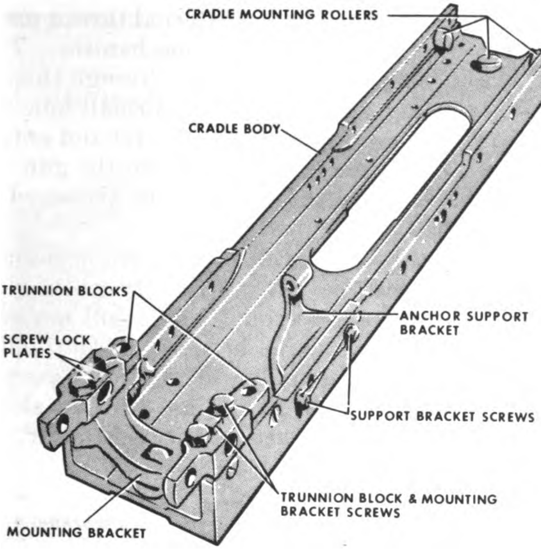


Figure 3–5.—Cradle assembly.

Description of Components

Cradle.—The cradle is the support member for attaching the gun to the airplane. It has five parts: cradle body, mounting bracket, trunnion blocks, cradle mounting rollers, and anchor support bracket.

Gun barrel.—The gun barrel is one piece of metal, externally threaded at both ends. It is attached to the front end of the receiver. A barrel locking pin, which passes through the receiver, prevents the barrel from vibrating loose during firing. The threads at the muzzle end may be used to attach a cone-shaped flash hider. The threads are covered by a thread-protector cap when the flash hider is not attached.

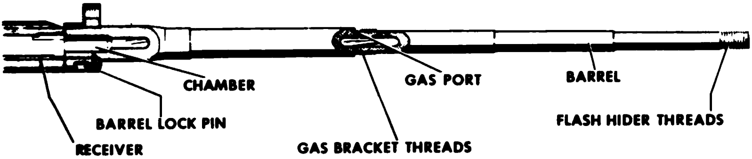


Figure 3–6.—20-mm gun; sectional view.

Near the center of the barrel is an external thread used for mounting the gas bracket of the gas mechanism. To the rear of this thread, the gas port is drilled through the top of the barrel into the bore. The gas port is a small hole which allows the propellant gases to leave the barrel and enter the gas mechanism. The recess on the bottom of the gun barrel at the breech end allows the empty case to be extracted from the chamber.

RECOIL MECHANISM.—The recoil mechanism cushions the shock of recoil, returns the gun to battery position, and cushions the shock of counterrecoil. The recoil mechanism consists of a recoil spring secured between a front and rear seat, and a recoil housing assembly. The recoil housing assembly consists of an internal sleeve, an external sleeve, a series of ring springs, and forward and rear follower.

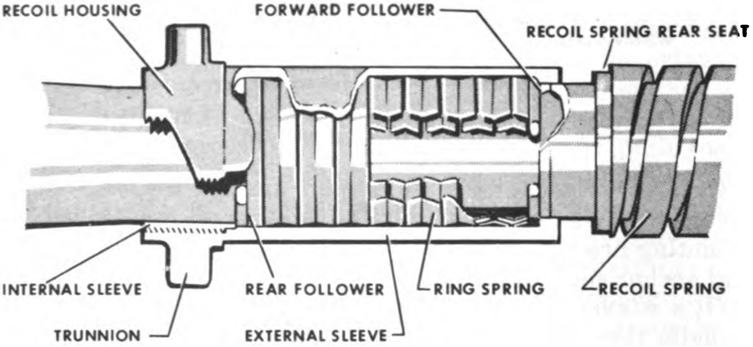


Figure 3–7.—Recoil housing assembly; sectional view.

RECEIVER.—The receiver is the supporting structure for the magazine slide assembly, the rear buffer, and the sear mechanism. In addition, it provides a mounting for the barrel and houses the breechblock and the driving spring guide assembly. The ammunition feed mechanism and the electric trigger are also supported by the receiver.

BREECHBLOCK.—The breechblock moves forward and back inside the receiver body and consists of the following parts: the bolt, two breechblock slides with slide springs and slide spring guides, two inertia blocks, a firing pin, extractor, extractor pin and spring, and breechblock lock (fig. 3–9).

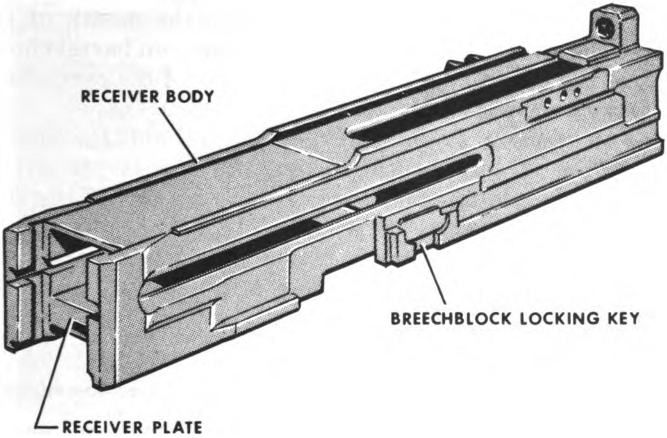


Figure 3–8.—Receiver; right rear view.

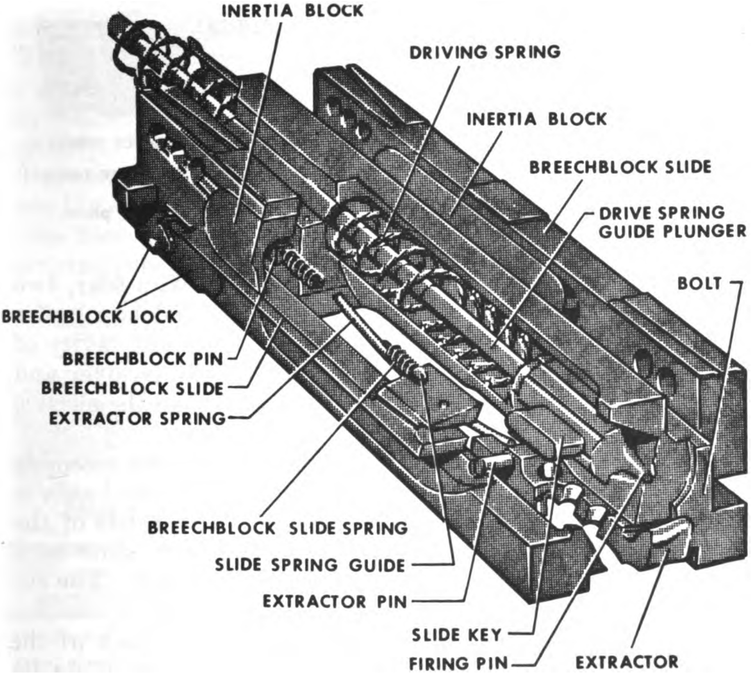


Figure 3–9.—Breechblock; sectional view.

The breechblock takes the round from the mouth of the feed mechanism, carries it forward into the gun barrel chamber, fires the round, and on its return toward the rear of the receiver, carries the empty case to the ejector.

Sear mechanism.—The sear mechanism holds the breechblock in the cocked position when the gun is not firing. When the electric trigger is energized, the sear of the sear mechanism is pulled free of the breechblock, allowing it to return to battery. At the end of a burst the sear mechanism stops the motion of the breechblock and absorbs the resulting shock.

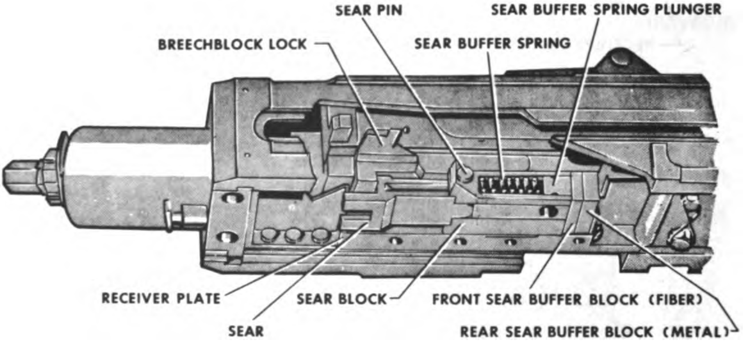

SEAR PIN
SEAR BUFFER SPRING PLUNGER
BREECHBLOCK LOCK
SEAR BUFFER SPRING
RECEIVER PLATE
SEAR BLOCK
FRONT SEAR BUFFER BLOCK (FIBER)
SEAR
REAR SEAR BUFFER BLOCK (METAL)

Figure 3–10.—Sear mechanism installed in cavity of receiver plate.

The sear mechanism consists of a sear block, a sear, two sear buffer blocks, two sear buffer springs, and two buffer spring plungers. The mechanism is housed in the cavity of the receiver plate on the rear underside of the receiver and is held in place by the cradle mounting plate and the electric trigger.

Magazine slide assembly.—The magazine slide assembly provides a secure mount for the feed mechanism and aids in the removal of the empty cartridge case. It consists of the magazine slide, latch, latch springs, slide lever, slide back plate, ejector, ejector springs, and the slide anchor. The entire assembly is nonrecoiling.

Rear buffer.—The rear buffer cushions the shock of the recoiling breechblock, stops its motion, and starts it on its forward or counter-recoil motion. It is secured to the re-

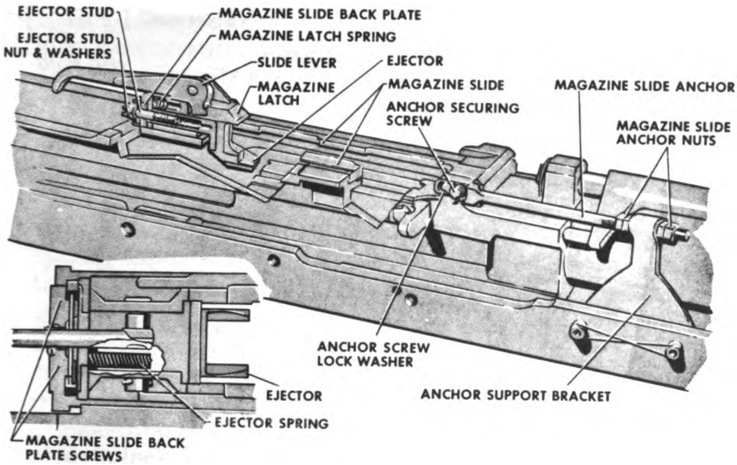


Figure 3–11.—Magazine slide assembly.

ceiver body by two vertical dovetail recesses on the rear of the receiver body and mating ribs on the rear buffer housing.

The rear buffer consists of a rear buffer housing, rear buffer ring spring, ring spring sleeve, coil spring, spacer sleeve, rear buffer washer, threaded sleeve, and lock plunger assembly.

Driving spring guide assembly.—The driving spring guide assembly drives the breechblock forward to strip a round out of the feed mechanism and chamber it ready to be fired by the firing pin. The main parts of the assembly are the driv-

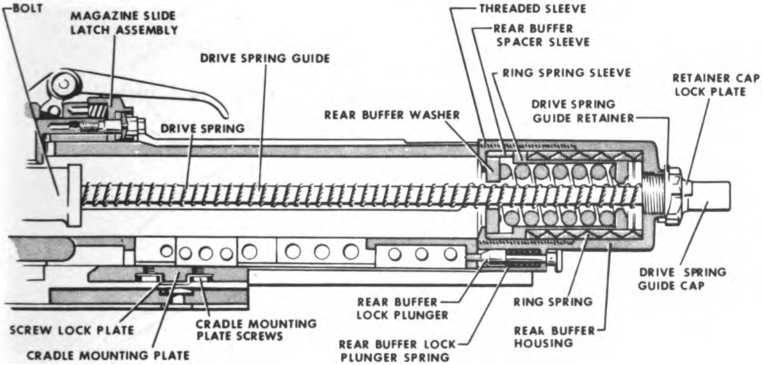


Figure 3–12.—Rear buffer; sectional view.

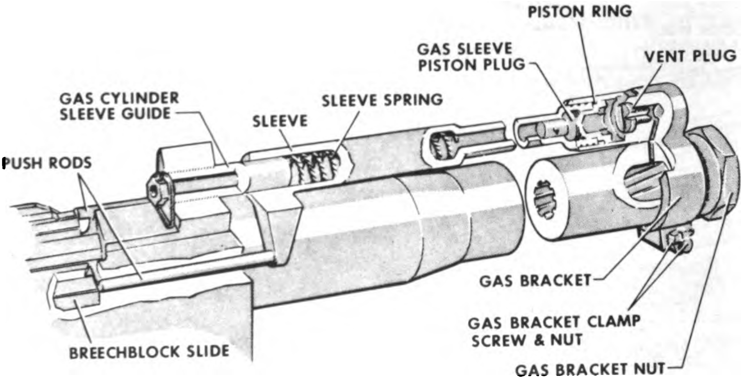


Figure 3–13.—Gas mechanism; sectional view.

ing spring guide, driving spring, and driving spring guide plunger.

Gas mechanism.—The gas mechanism supplies the force which unlocks the breechblock and retracts the firing pin. The principal parts of the gas mechanism are the gas bracket, gas cylinder sleeve assembly, gas cylinder sleeve guide, gas cylinder sleeve spring, and two push rods.

The gas bracket receives the propellant gas and directs it against the gas cylinder sleeve assembly. This assembly moves rearward, contacting the two push rods. These rods transmit the energy of the propellant gas to the breechblock slides, forcing them rearward. This action unlocks the breechblock and retracts the firing pin.

Cycle of Operation

The cyclic functioning of the gun as a whole is divided into the following actions for purposes of explanation:

Recoil
Breechblock unlocking
Breech opening
Case ejection
Buffer and driving spring action
Cocking action
Breech closing
Breechblock locking
Firing

In addition to the cyclic actions, the feed mechanism operates concurrently to furnish ammunition to the gun. This action is described later.

Recoil.—When the round is fired, the pressure of the propellant gases in the gun barrel forces the gun to recoil in the following manner: The recoil spring front seat and the barrel move to the rear, compressing the recoil spring (fig. 3–14). The recoil spring is compressed until the recoil spring front seat contacts the recoil spring rear seat. At this point the shock of recoil is transmitted to the ring spring. While the ring spring is being compressed the recoil spring begins to recover, thus moving the gun forward in counterrecoil. The ring spring then acts as a counterrecoil buffer if the gun should travel past its battery position.

Breechblock unlocking.—At the moment of firing, the breechblock is held against the breech of the gun barrel by the breechblock lock resting on the breechblock locking key.

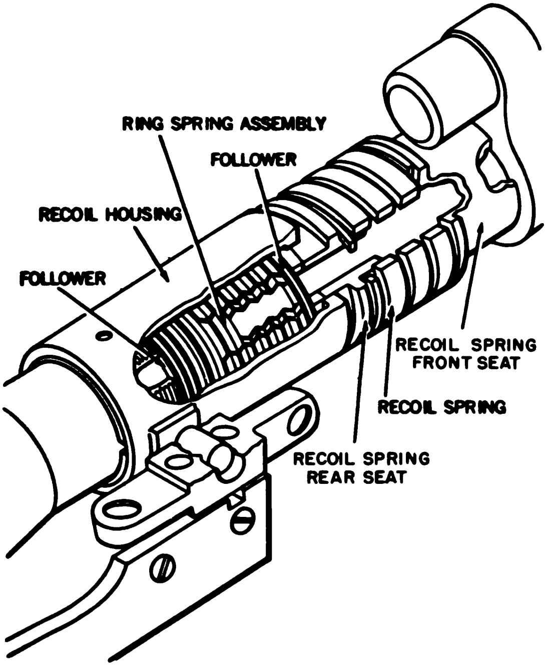


Figure 3–14.—Recoil action; springs at near maximum compression.

The breechblock slides prevent the breechblock lock from disengaging until after firing.

The action of the gas mechanism unlocks the breech. As the projectile is driven forward in the gun barrel, it passes the gas port. A portion of the expanding propellant gas enters the gas port and passes into the cylinder portion of the gas bracket. There the gas passes through the hole in the vent plug and exerts pressure on the gas cylinder sleeve assembly. As the gas expands against the gas cylinder sleeve assembly, the gas forces the gas cylinder sleeve assembly to the rear, compressing the gas cylinder sleeve spring.

As the gas cylinder sleeve assembly is forced to the rear, the yoke on the rear end of the sleeve assembly contacts the two push rods and forces them rearward (fig. 3–15). The push rods, in turn, contact the breechblock slides and force the slides to move rearward.

The breechblock slides are connected by the breechblock slide key which actuates the firing pin. The firing pin is notched to fit over the breechblock slide key (fig. 3–9). Therefore, as the breechblock slides move rearward, the breechblock slide key retracts the firing pin.

As the slides near the end of their rearward motion, the

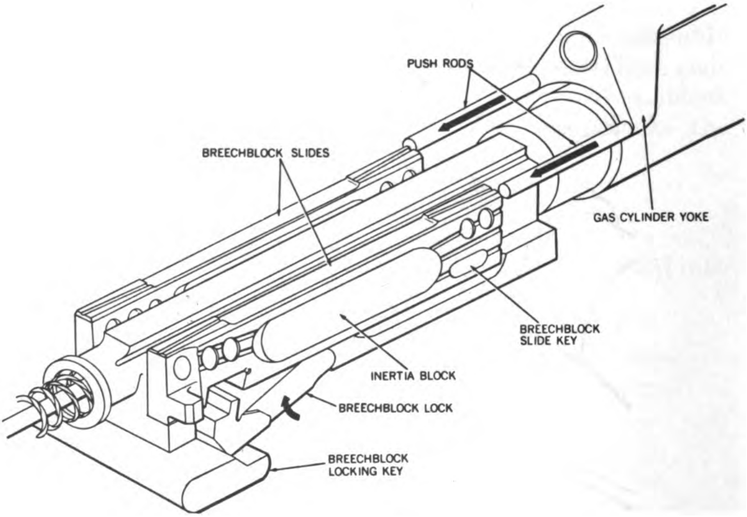


Figure 3–15.—Breech unlocking action; slides being forced rearward by push rods.

rear lugs of the breechblock lock are uncovered allowing the lock to rise clear of the breechblock locking key, thereby unlocking the breechblock.

Breech opening.—After unlocking, the breechblock is started to the rear by the blowback action of the expanding gases that remain in the gun barrel. As the breechblock moves to the rear, it causes a drop in the gas pressure in the barrel. When the gas pressure drops, the gas cylinder sleeve spring expands, returning the gas cylinder sleeve assembly to its original position. The extractor claw (fig. 3–16) is engaged with the extracting groove of the empty cartridge case and aids in withdrawing the case from the chamber.

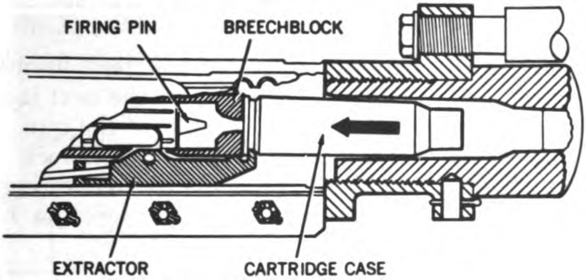


Figure 3–16.—Cartridge extraction; breechblock being blown to the rear.

Case ejection.—As the breechblock is forced to the rear, the empty case is moved back with the breechblock by the pull of the extractor claw against the cartridge case rim. Near the completion of the breechblock rearward motion, the empty case is contacted on the upper edge by the two ejector prongs of the magazine slide assembly (figs. 3–11 and 3–17). This forces the empty case to pivot downward over the forward end of the extractor and through the openings in the bottom of the receiver and the cradle.

During ejection, the front end of the extractor is forced downward, thereby compressing the extractor spring. After the empty case is free from the extractor, the extractor spring returns the extractor to its original position.

Buffer and driving spring action.—When the breechblock has traveled sufficiently to the rear, a new round of ammunition is forced downward into the mouth of the feed

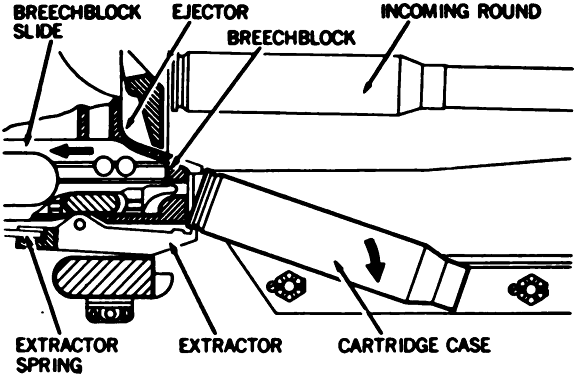


Figure 3–17.—Case ejection; case being pivoted over extractor claw.

mechanism by the driving spring of the feed mechanism. In recoiling, the breechblock passes under the next incoming round and compresses the driving spring of the gun. Near the end of its rearward movement, the breechblock strikes the rear buffer washer which transmits the remaining force of recoil to the buffer springs. This brings the breechblock to a stop (fig. 3–18).

The inertia blocks, however, continue to move rearward in their slots in the breechblock slides until they reach the end of the slots. By this time the rear buffer springs and

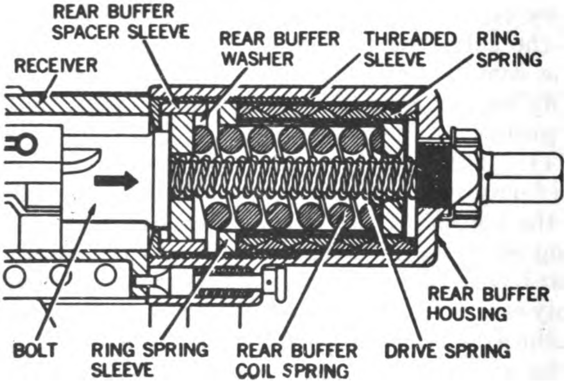


Figure 3–18.—Buffer and driving spring near full compressed position; bolt to the rear.

driving spring, which were compressed during recoil, have started to expand and drive the breechblock forward. The inertia blocks remain in the rearward position, relative to the breechblock slides, during the forward motion of the breechblock and slides.

Cocking action.—During the rearward movement of the breechblock, it passes over and depresses the sear of the sear mechanism. If the sear is not held down by the electric trigger, it will engage a recess in the breechblock lock, as the breechblock starts forward. This holds the breechblock in the rear of the gun (fig. 3–19). The shock produced when the sear and the breechblock lock engage is absorbed by the sear buffer springs and the sear buffer blocks. When the electric trigger is actuated, thereby pulling the sear down, the breechblock will move forward into battery position by the action of the compressed driving spring.

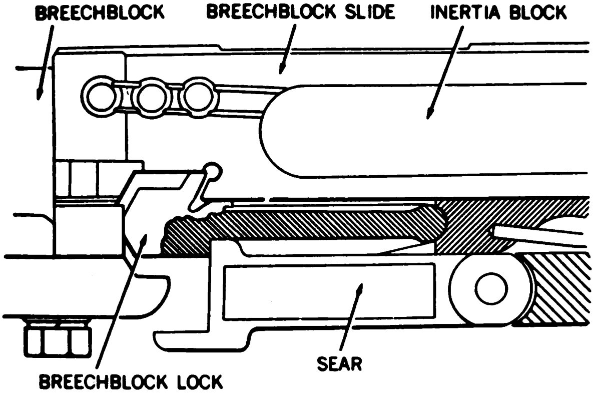


Figure 3–19.—Cocking action; sear in sear pocket of lock.

Breech closing.—As the breechblock moves forward, it engages the next incoming round of ammunition which has been positioned in the mouth of the feed mechanism (fig. 3–20). This round was forced downward into the feed mouth when the recoiling breechblock had sufficiently cleared the feed mechanism. Near completion of the breechblock closing stroke, the cartridge drops into the recess in the front of the bolt and is forced into the gun barrel chamber (fig. 3–21). As the round is chambered, the bottom of the

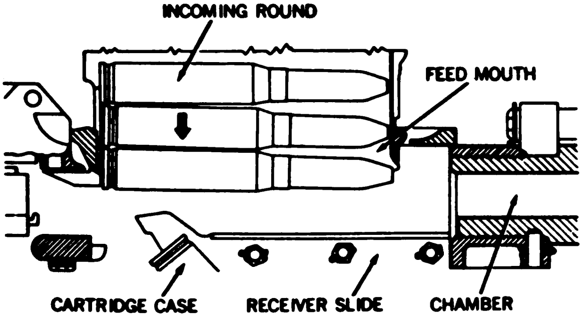


Figure 3–20.—Chambering action; bolt starting forward.

cartridge case extracting groove is engaged by the extractor claw.

Breechblock locking.—When the breechblock reaches the end of its forward motion, it seats against the rear face of the gun barrel, thereby closing the chamber. The action of the slide springs combined with the momentum of the slides causes the slides to continue forward after the breechblock stops (fig. 3–22). At the same time, the projecting cams on each side of the breechblock lock are engaged by the cam surfaces on the receiver slides. The action of the cams on the bevel of the breechblock lock forces the lock to rotate downward. The breechblock lock seats against the breechblock locking key in the receiver and is held in this position by the rear lower surface of the breechblock slides bearing on the rear end of the lock, as shown in figure 3–3.

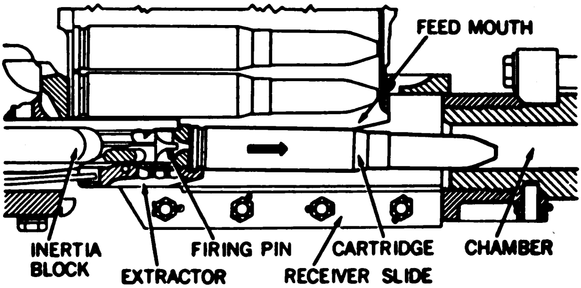


Figure 3–21.—Breechblock closing action; cartridge entering chamber.

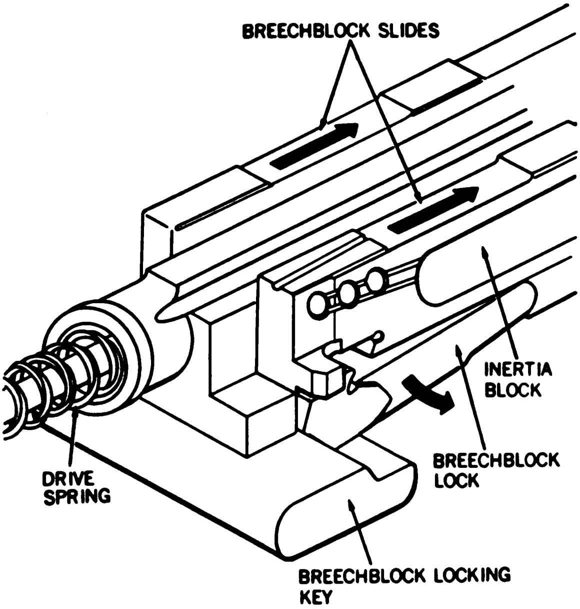


Figure 3–22.—Breechblock locking action.

FIRING.—The firing pin is carried forward by the breechblock slide key, which is attached to the breechblock slides, and by the force of the expanding driving spring. This causes the firing pin to strike the cartridge primer and fire the round (fig. 3–23).

When the slides have reached the end of their forward motion, the inertia blocks continue to move forward in their slots until they strike the forward end of the slots (fig. 3–24). This eliminates any tendency to rebound that the slides or firing pin may have.

During the automatic firing, the electric trigger holds the sear of the sear mechanism downward, away from the breechblock lock. This allows the breechblock to move through its cycle without being caught or held at the rear of the gun.

To stop firing the gun, the electric trigger switch is released, allowing the sear to be forced upward by pressure from the sear spring plunger and sear return spring in the sear return nut. (See fig. 3–33.) Its top surface engages the recess in the breechblock lock, thus holding the breechblock in the retracted position.

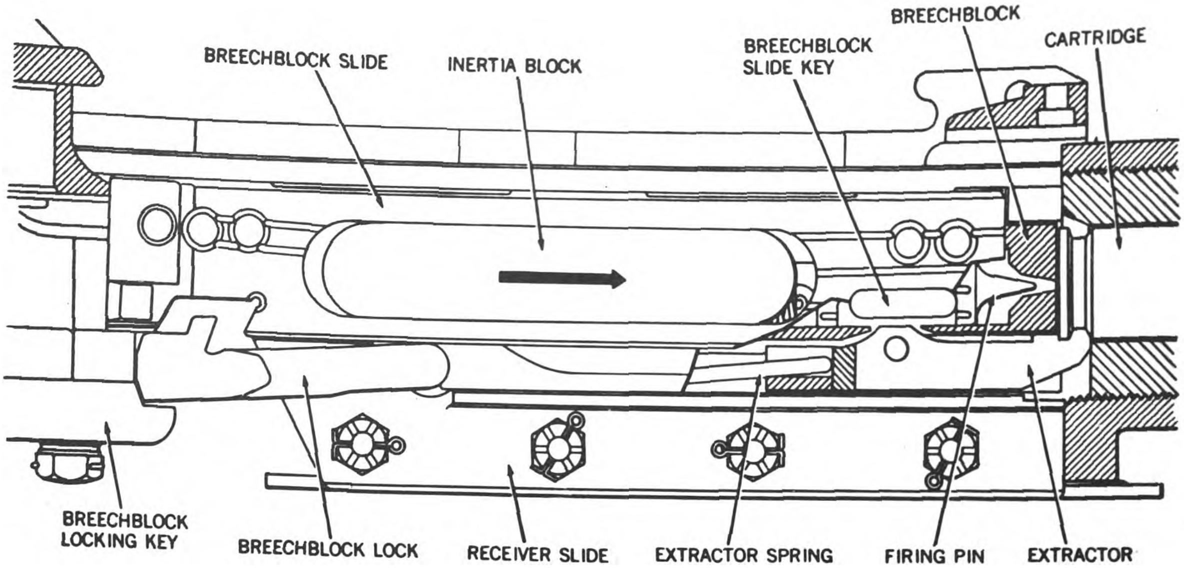


Figure 3–23.—Firing action; bolt forward, lock in locked position.

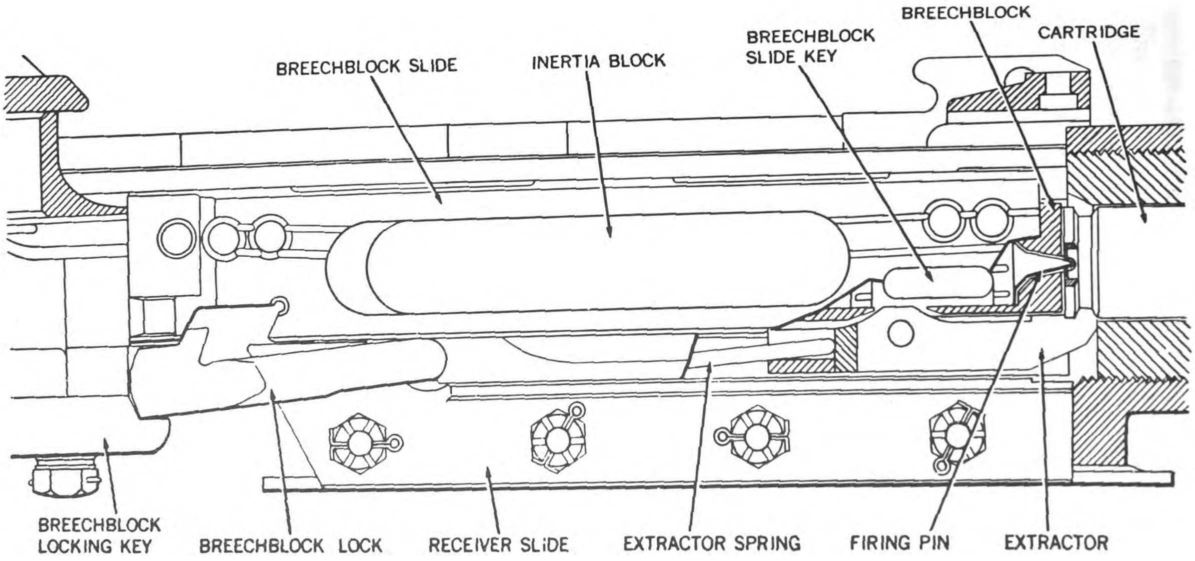


Figure 3–24.—Firing action; bolt in forward position, firing pin in contact with cartridge.

FEED MECHANISM AN–M2

General Description

The 20-mm Feed Mechanism AN–M2 is a complete unit used to feed belted ammunition to the M3 gun. There are two distinct feed mechanisms, one which feeds ammunition to the gun from the right-hand side and the other which feeds from the left. The feed mechanism is furnished with a feed chute adapter which gives an ammunition entrance angle of 75 degrees above the horizontal. A feed cover (not furnished with the unit) can be inserted between the feed chute adapter and the feeder frame when it is necessary to change the ammunition entrance angle. The various covers available give entrance angles varying from 55 degrees above the horizontal to 47 degrees below the horizontal.

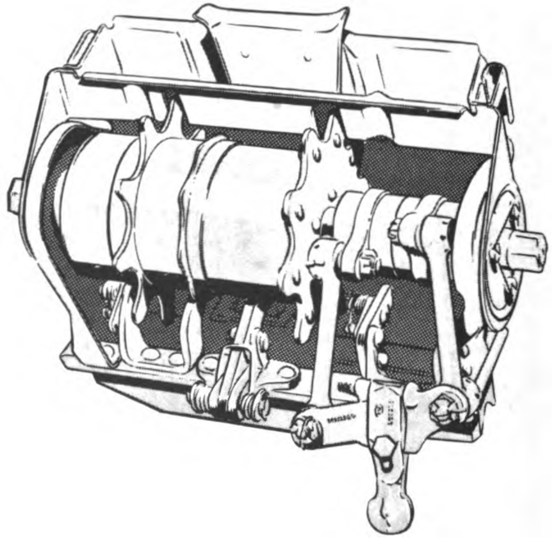


Figure 3–25.—Right-hand Feed Mechanism AN–M2; rightside view.

The function of the feed mechanism is to bring belted ammunition to the gun; separate the rounds from the links; and feed the rounds, one at a time, into the gun. The mechanism is operated by the recoil and counterrecoil of the gun.

The feed mechanism is mounted on the nonrecoiling magazine slide assembly and remains stationary during the recoil of the gun. The operating lever bracket, which is secured to the recoiling receiver, actuates the feed mechanism.

Detailed Description

There are three major assemblies in the feed mechanism:

Frame assembly
Starwheel housing assembly
Clutch drive assembly

FRAME ASSEMBLY.—The frame is the base of the feed mechanism and the housing for the operating parts. It also positions the rounds as they are fed into the gun.

The frame assembly (fig. 3–26) consists of the following parts:

Frame
Feed mouth
Two stripper cams
Link deflector
Link operating crank bracket
Cartridge control pawl bracket
Cartridge control pawl
Front and rear cartridge guides
Front and rear cartridge holding cams

The FRAME provides a support for the starwheel housing assembly and the clutch drive assembly. A rectangular opening at the base of the frame allows ejection of the ammunition belt links. The two link stripper cams are fastened to the frame just above the rectangular opening (fig. 3–26).

The FEED MOUTH provides a rigid mounting for the frame. It also receives and guides the movement of the cartridge. In addition, the feed mouth supports the link operating crank bracket, the rear cartridge guide, and the cartridge control pawl bracket.

The two STRIPPER CAMS wedge between each cartridge case and the two projections of the ammunition belt links. This action detaches the links from the case.

The front (or inner) edge of each stripper cam is a guide for the round after it has been detached from its link. (See fig. 3–30.) The rear (or outer) edge of each stripper cam is a guiding surface for the detached link. The links fol-

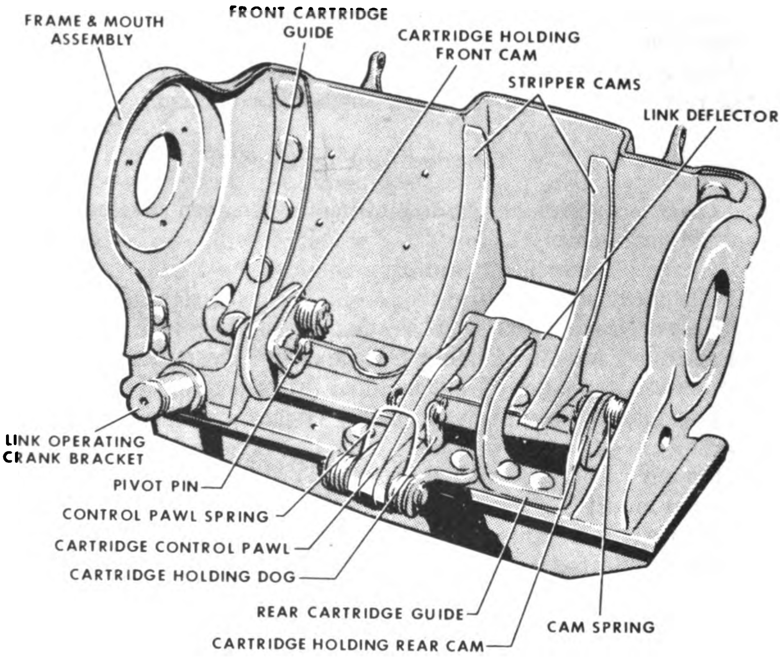


Figure 3–26.—Feed Mechanism AN–M2; components of frame assembly.

low the rear edges of the stripper cams down and out of the link ejection chute.

The LINK DEFLECTOR assists in guiding the ammunition belt links out of the feed mechanisms after they have been stripped from the rounds. The link deflector is a V-shaped stamping attached to the feed mouth between the two stripper cams.

The LINK OPERATING CRANK BRACKET supports the front cartridge guide and also provides a pivot surface for the link operating crank of the clutch drive assembly.

The CARTRIDGE CONTROL PAWL BRACKET supports the cartridge control pawl and the cartridge control pawl spring.

The CARTRIDGE CONTROL PAWL, along with the cartridge holding dog, controls the movement of the cartridge into the feed mouth. The cartridge control pawl is a lever pointed at one end and pivoted at the other end to the control pawl bracket. The cartridge holding dog, pinned to the approximate center of the control pawl, extends downward into the feed mouth. The cartridge holding dog is held in the downward position by the cartridge control pawl spring. Just before the incoming rounds enter the feed mouth, they contact the lower edge of the cartridge control pawl, raising it slightly. This action lifts the cartridge holding dog, allowing the cartridges to enter the feed mouth.

The FRONT AND REAR CARTRIDGE GUIDES assist in guiding the incoming rounds into the feed mouth. They also support the front and rear cartridge holding cams. The front cartridge guide is a flat cam-shaped plate. The rear cartridge guide is a U-shaped bracket, the sides of which are cam-shaped. (See fig. 3–31.)

The FRONT AND REAR CARTRIDGE HOLDING CAMS prevent the rounds from reentering the path of the starwheel housing assembly after they have been forced into position in the feed mouth.

STARWHEEL HOUSING ASSEMBLY.—The starwheel housing assembly regulates the drive spring load to prevent overwinding of the spring. In addition, it houses the drive spring and brings the incoming rounds of ammunition into the feed mechanism.

The starwheel housing assembly (figs. 3–27 and 3–28) consists of the main drive shaft assembly, the drive spring, the starwheel housing, the drive spring release mechanism, and the drive spring release shaft.

The MAIN DRIVE SHAFT ASSEMBLY winds the drive spring. The assembly is rotated by the clutch drive assembly and consists of the main drive shaft and the drive spring driver (fig. 3–28).

The main drive shaft is a solid cylindrical rod. The manual drive nut, which is used to manually wind the drive spring, is pinned to the front of the shaft.

The drive spring driver is a cylinder with a projecting shoulder. The driver is positioned inside the small end of the feed mechanism drive spring.

The DRIVE SPRING stores the required energy to drive the feed mechanism. It is a coil spring with two diameters. The large diameter of the spring consists of approximately 16 turns and is the portion of the spring where the energy of recoil and counterrecoil is stored for feeding the ammunition to the gun. The small diameter, consisting of approximately six turns, fits snugly over the drive spring driver hub. A lug on the rear end of the drive spring engages the projection of the driving mechanism end in the rear of the starwheel housing (fig. 3–27). This functions to regulate the drive spring torque and prevent overwinding of the spring. The small hook on the front of the spring engages the drive spring anchor on the back of the front starwheel. This arrangement rotates the starwheel housing as the drive spring unwinds, releasing its energy.

The STARWHEEL HOUSING is a hollow cylinder enclosing the drive spring and drive spring release mechanism. The driving mechanism end is riveted to the inside at the rear of the housing. The rear starwheel and link guide ring are welded to the exterior of the housing (fig. 3–28). The front starwheel is riveted to the front of the housing.

As the starwheel housing rotates, the two starwheels engage the incoming rounds drawing them into the feed mechanism. Each starwheel is a sprocket with nine teeth contoured to fit between the cartridge cases in the ammunition belt. Riveted to the rear side of the front starwheel is the drive spring anchor which engages a hook on the front end of the drive spring. This secures the drive spring to the front starwheel.

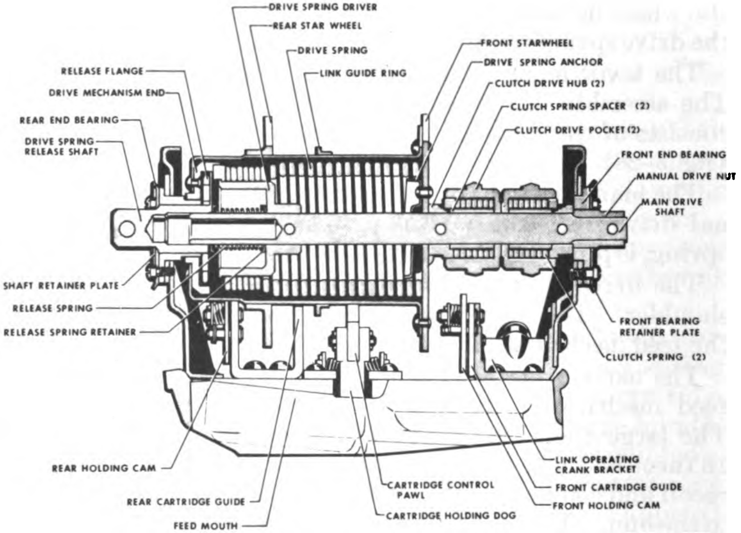


Figure 3–27.—Feed Mechanism AN–M2; sectional view.

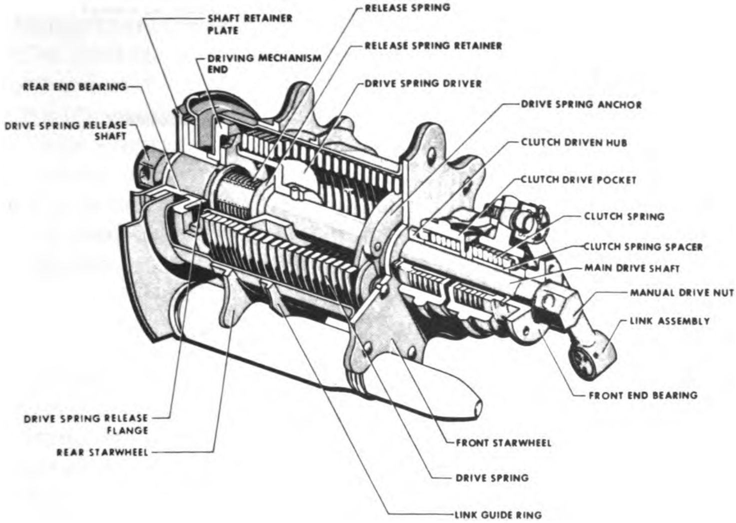


Figure 3–28.—Feed Mechanism AN–M2; cutaway view.

The **drive spring release mechanism** provides a means of unwinding the drive spring. It consists of the drive spring release flange, the release spring, and two release spring retainers (fig. 3–28).

The **drive spring release flange** is mounted over the main drive shaft. The six projections on the outside diameter engage the lug on the rear end of the drive spring.

The **drive spring release shaft** provides a means of winding or unwinding the drive spring by engaging the drive spring release flange. The shaft is cylindrical with a hexagon-shaped head and a hole at the rear. The front of the shaft has two projecting lugs and an inside diameter which allows it to slip over the rear of the main drive shaft. It is held in place by the shaft retainer plate (fig. 3–28). The drive spring can be unwound by using a wrench on the hexagonal head or a bar in the hole at the rear of the shaft.

Clutch drive assembly.—The clutch drive assembly winds the feed mechanism drive spring and maintains the proper tension on the spring. It consists of the operating lever, link operating crank, two link assemblies, and two clutch drive pocket assemblies (fig. 3–29).

The **operating lever** transfers the recoiling motion of the

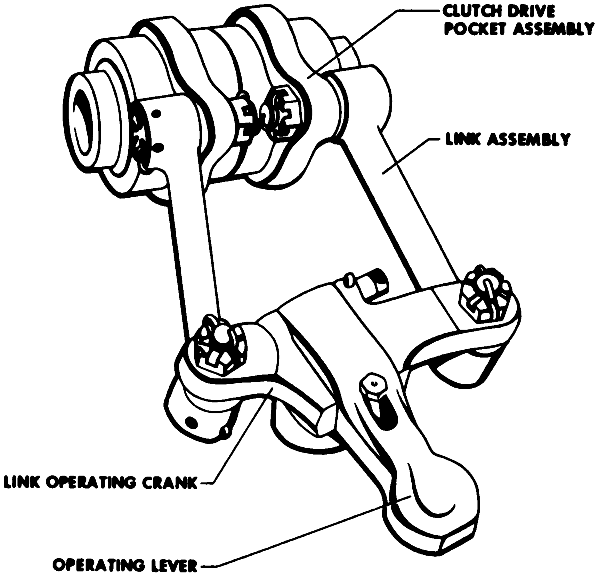


Figure 3–29.—Clutch drive assembly.

gun to the link operating crank. A spring-loaded latch in the operating lever locks the lever to the link operating crank. When removing the feed mechanism from the gun, it is necessary to depress the latch before the operating lever can be disengaged from the link operating crank.

The LINK OPERATING CRANK receives motion from the operating lever to actuate the link assemblies.

Two LINK ASSEMBLIES provide a connection between the link operating crank and the clutch drive pocket assemblies.

Two CLUTCH DRIVE POCKET ASSEMBLIES, each consisting of a clutch drive pocket, clutch spring, and clutch-driven hub, turn the main drive shaft continuously in one direction as long as the gun is firing.

The clutch drive pockets are circular steel forgings with a recess at one side to accommodate the clutch spring. An arm on the outside diameter of the pockets provides a means of connecting the pockets to the link assemblies.

The operating linkage and the direction of winding of the clutch springs are arranged so that the rear clutch drive pocket, during recoil, transmits motion to the main drive shaft, while the front clutch drive pocket is freewheeling. During counterrecoil, the action of the front and rear clutch drive pockets is reversed. This arrangement converts the forward and backward motion of the operating lever into a rotary motion which actuates the main drive shaft.

Feed chute adapter.—The feed chute adapter provides an entrance for the ammunition into the feed mechanism and also a means of attaching the feed chute. When used without a feed cover, it gives an ammunition entrance angle of 75 degrees above the horizontal.

Cycle of Operation

As previously described, firing of the gun causes the receiver to recoil. The action of the rear buffer and the driving spring imparts counterrecoil motion to the receiver and returns it to the firing position. It is a part of this recoil and counterrecoil energy that is utilized to drive the feed mechanism.

The operating lever bracket moves with the recoil and counterrecoil of the gun. The operating lever bracket engages the operating lever which, in turn, causes the link operating crank to pivot on the link operating crank bracket.

The pivoting motion of the link operating crank causes the two link assemblies, which connect the link operating crank with the clutch drive pockets, to be pushed upward alternately. This action rotates the clutch drive pockets. The rear clutch drive pocket transmits motion to the main drive shaft through the clutch spring and clutch-driven hub during recoil, while the front clutch freewheels. During counterrecoil, action of the front and rear clutches is reversed. Thus, the forward and backward motion of the operating lever is converted to rotary motion to actuate the main drive shaft and wind the feed mechanism drive spring.

In the clutch drive pocket that is rotating in a direction to wind the feed mechanism, friction between the outer surface of the clutch spring and the inner surface of the clutch drive pocket tends to unwind the clutch spring. This unwinding increases the clutch spring diameter and causes it to grip the clutch drive pocket and to be carried with the pocket as it rotates. A bent projection at the outside end of each clutch spring fits into a slot in the corresponding clutch-driven hub. The clutch-driven hubs are pinned to the main drive shaft, therefore, when they are rotated by the clutch springs, the shaft turns with them.

As one clutch drive pocket is rotating in the winding direction, the other rotates in the opposite direction. The effect of this rotation of the latter clutch drive pocket tends to wind its clutch spring, reducing the spring diameter and relaxing the spring's grip on the clutch drive pocket. This permits the pocket to rotate in the opposite direction of its clutch spring and its clutch-driven hub, both of which always rotate with the main drive shaft. This action of the winding mechanism components turns the main drive shaft continually in one direction, even though the direction of motion of the clutch drive pockets is reversed after every half cycle of gun operation.

As the main drive shaft rotates, it carries the drive spring driver which is pinned to the shaft. The drive spring driver is positioned inside the small end of the drive spring (fig. 3–28). The drive spring is ground to fit snugly over the outside surface of the drive spring driver.

The winding of the drive spring is similar in operation to the winding of the clutch springs, except that the drive spring grips with the inside edges instead of with the outside edges. As the driver rotates, the friction between the drive spring driver and the drive spring winds the spring. This reduces the spring's diameter and causes the spring to grip and revolve with the driver. This winds the larger portion of the drive spring, and the energy that is transmitted by the main drive shaft is stored in the drive spring. The front end of the drive spring is fastened to the front starwheel by the drive spring anchor (fig. 3–28). As the drive spring unwinds, it releases its stored energy by rotating the starwheel housing and the attached front starwheel. This action feeds the rounds into the gun.

The drive spring may store energy, or wind up, faster than it can release energy, or feed the rounds to the gun. To prevent this overwinding of the drive spring, the feed mechanism employs a torque stabilizing action which regulates the drive spring torque from 23 to 27 pound-feet. The clutch end of the drive spring is bent over at 90 degrees, producing a projection. If the drive spring is wound at a faster rate than the starwheel housing can rotate, the spring will rotate until its projection contacts the protruding lug of the driving mechanism end (fig. 3–28). The resultant pressure exerts a force on the small coils of the drive spring, that is opposite to the winding direction. This causes them to relax their grip on the drive spring driver, until the driver can revolve freely within the drive spring and still maintain full drive spring torque. The contact of the drive spring projection with the lug of the driving mechanism end prevents further winding of the drive spring.

To unwind the drive spring manually, place a wrench on the drive spring release shaft which rides in the rear end bearing (fig. 3–28). By pushing the shaft inward, the release spring is compressed and the drive spring release flange is shifted until one of its notches engages the projection of the drive spring. If the drive spring release shaft is revolved in the direction opposite to that of winding, the release flange will exert a force on the drive spring through the projection, causing it to relax its grip on the drive spring driver. This allows the drive spring to be revolved on the

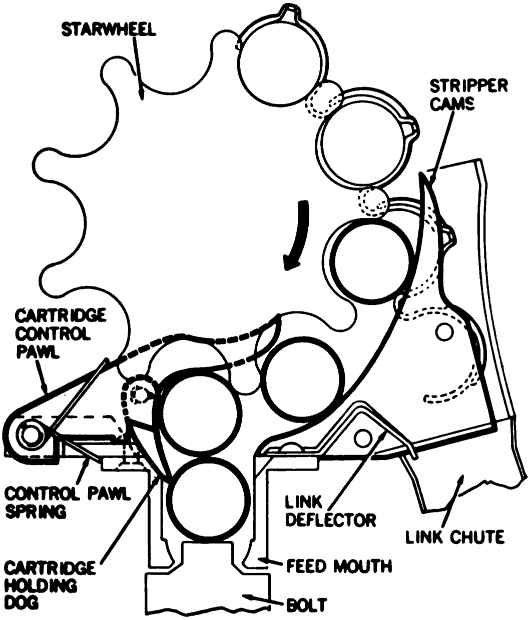


Figure 3–30.—Feed Mechanism AN–M2; stripper cam action.

driver by the rotation of the drive spring release shaft and flange. This action unwinds the spring. Expansion of the release spring returns the drive spring release flange and the drive spring release shaft to their original positions.

As the starwheel housing rotates, it draws the loaded ammunition belt into the feed mechanism. The rear starwheel engages the cartridge case to the rear of the belt link and the front starwheel engages the projectile just ahead of the rotating band.

As the belt rotates with the starwheel housing assembly, the two stripper cams wedge between each cartridge case and the two projections of the belt links, thereby detaching the links from the case. The two projections of the belt links slip over the ends of the stripper cams and follow the rear edges of the cams downward and out of the link chute (fig. 3–30). The link deflector directs the single end of the link into the link chute, while the double end is being cammed from the

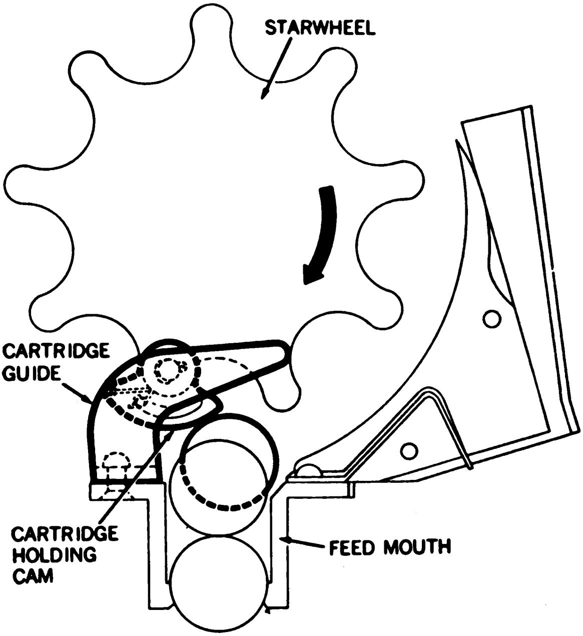


Figure 3–31.—Feed Mechanism AN–M2; cartridge holding cam action.

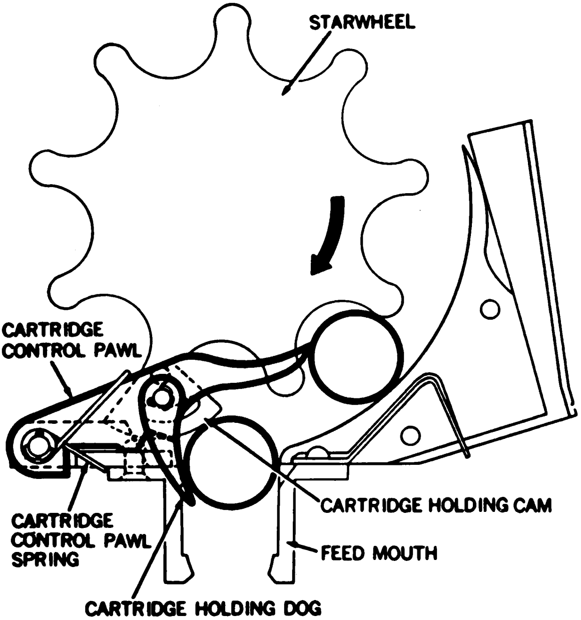


Figure 3–32.—Feed Mechanism AN–M2; cartridge control pawl and cartridge holding dog action.

cartridge case. After the links have been stripped from the cartridge case, the case is forced forward along the front surfaces of the stripper cams by the starwheels. When the cartridge is in line with the feed mouth, it contacts the front cartridge guide and the rear cartridge guide. These guides serve to start the cartridge downward into the feed mouth and out of the recesses of the starwheels (fig. 3–31). A spring-loaded cartridge holding cam is attached to each of the cartridge guides. These cams are forced aside as the round enters the feed mouth. They prevent the rounds from reentering the path of the starwheels. These cams also hold the round in position in the feed mouth if the feed mechanism drive spring loses tension.

Just before the incoming cartridges enter the feed mouth, they contact the lower edge of the spring-loaded cartridge control pawl, raising it slightly. This raises the cartridge holding dog and allows the cartridges to enter the feed mouth (fig. 3–32). The cartridge passes to the bottom of the feed mouth and is held in position by the force exerted by the starwheels through the cartridge above. The cartridge to be fired is forced downward on top of the breechblock when it is in the forward position. As the breechblock recoils, ejecting the empty cartridge case, the incoming cartridge is forced into a position in the feed mouth, where it is carried forward by the breechblock during its forward travel.

When the last cartridge of an ammunition belt passes under the cartridge control pawl and enters the feed mouth, the pawl is forced downward by the cartridge control pawl spring. This action lowers the cartridge holding dog. This prevents the last cartridge from dropping completely down into the feed mouth but positions the cartridge low enough to permit the starwheels to spin as the drive spring is unwound. Should the last cartridge drop into the path of the breechblock (without the pressure of following rounds, as is normal), it would cause the gun to jam. The cartridge holding cams prevent the last cartridge from tilting, and lessen the possibility of the cartridge being struck by the breechblock.

As incoming cartridges enter the feed mouth, they contact the front and rear spring-loaded cartridge holding cams, forcing them aside. When the last cartridge leaves the starwheels and enters the feed mouth, the cartridge holding cams are forced over the top of the cartridge by the cartridge holding cam springs. The cartridge holding cams prevent the last two cartridges from reentering the path of the starwheels. They also assure proper horizontal alignment of the last cartridge and, therefore, the cartridge below it, so that the lower cartridge can be properly contacted by the counterrecoiling breechblock.

ELECTRIC TRIGGER CONTROLS

Electric Trigger AN–M4

The Electric Trigger AN–M4 is a complete unit designed to fire the M3 gun by remote control. It operates on a 24-volt electrical system and draws a maximum of 8 amperes. The principal components are the sear cover plate, the solenoid assembly, and the sear return nut assembly (fig. 3–33).

SEAR COVER PLATE.—The sear cover plate provides a means of mounting the solenoid assembly to the bottom of the gun.

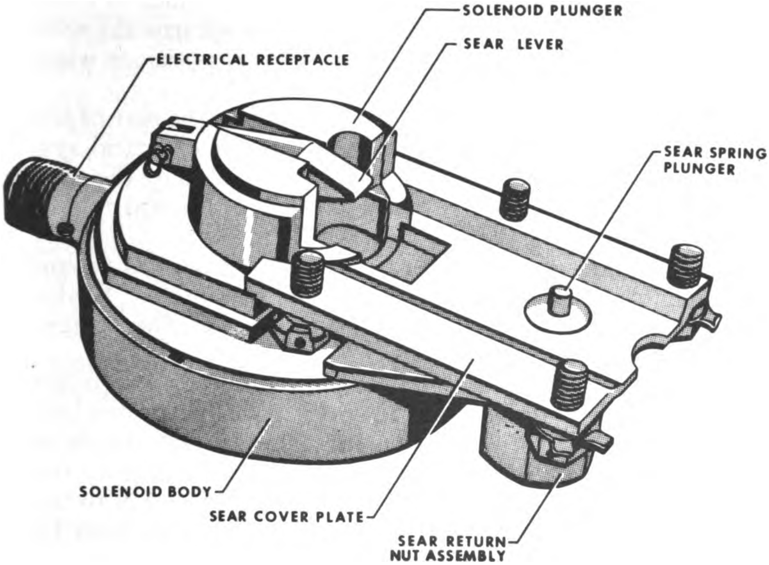


Figure 3–33.—Electric Trigger AN–M4.

Four cap screws and two lock plates secure the sear cover plate to the bottom of the receiver plate.

A threaded hole to the front of the sear cover plate accommodates the sear return nut assembly which attaches the solenoid assembly to the sear cover plate. A cam surface on the inside face of the plate, to the rear of the threaded hole, insures positive engagement of the sear with the breechblock lock by its camming action on the sear. This action occurs when the sear is forced forward against the sear buffer springs by the breechblock.

SOLENOID ASSEMBLY.—The solenoid assembly creates a magnetic field which, by means of a mechanical linkage, draws the sear out of the path of the breechblock.

The solenoid assembly consists of a solenoid mounted in the solenoid body, a solenoid plunger with an attached sear lever, a solenoid spring, and an electric receptacle. When the solenoid is energized a magnetic field is created which draws the solenoid plunger and the sear lever into the solenoid against the tension of the solenoid spring inside the plunger. This action pulls the sear toward the trigger, since the sear lever engages the sear. This allows the breechblock to move forward into battery. The solenoid spring returns the solenoid plunger and sear lever to their original positions when the trigger switch is released.

The electric receptacle, which is mounted on the rear of the solenoid assembly, connects the trigger to the electrical system of the airplane. The magnetic force created by the solenoid is sufficient to fire the gun regardless of the attitude of the aircraft in which the gun is installed.

SEAR RETURN NUT ASSEMBLY.—The sear return nut assembly mounts the solenoid assembly to the sear plate. It also returns the sear to its original position when the trigger switch is released.

The sear return nut assembly consists of a sear return nut body with a spring-loaded sear spring plunger protruding from the body. The sear return nut passes through a hole in the solenoid body and screws into the threaded hole in the sear cover plate. This mounts the solenoid assembly to the sear cover plate. The sear spring plunger is depressed by the sear when the electric trigger is energized. When the current input is discontinued, the sear spring plunger is forced upward by the sear spring in the sear return nut body, and acts upon the sear to return it to its initial position where it will engage the breechblock lock, as described earlier in the chapter.

Electric Trigger AN–M1A1

Another electric trigger frequently used with the M3 gun is the AN–M1A1. Since the AN–M1A1 is identical to the AN–M4 in principle of operation the unit is not described in this text.

GUN CHARGERS

The gun charger retracts the breechblock to cock the gun or to remove a round from the chamber. Charges available for the M3 gun are operated manually, hydraulically, or pneumatically. The manual charger is operated by pulling the charger cable to the rear until the breechblock is cocked, then allowing the cable to return by spring action. The hydraulic charger is powered by fluid under pressure supplied from the airplane's hydraulic system. The pneumatic charger is powered by compressed air or gas supplied from a storage cylinder.

Hydraulic Charger Aero 13A

There are several hydraulic chargers available for use with the M3 gun. All these chargers are very similar, therefore, only the Aero 13A is described here.

The charger consists of a long cylindrical tube containing a spring-loaded piston with a spring guide at one end. The piston has a protruding shoulder (driving lug) which engages the breechblock slide to charge the gun. A bracket and spring latch are provided for installing the charger on the gun. A swivel connection is located at the forward end of the charger for connecting it to the airplane's hydraulic system. Pressure to the charger is controlled by a solenoid control valve. The charger is shown in normal (forward) position in figure 3–34.

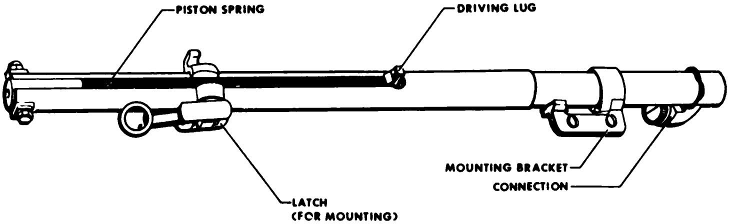
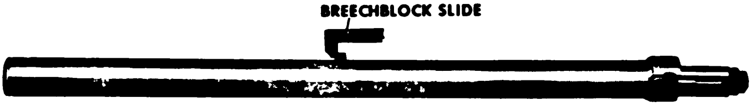


Figure 3—34.—Hydraulic Charger Aero 13A.

When the charger is operated, hydraulic fluid under pressure enters the cylinder at the swivel connection, forcing the piston to the rear against the force of the piston return spring. As the piston is forced to the rear, the driving lug engages the breechblock slide and moves the breechblock to the rear against the force of the driving spring. As long as pressure is maintained on the piston, the charger will remain in the recoil or SAFE position. When the pressure on the piston is allowed to drop, the piston is returned to battery position by the piston return spring.

Pneumatic Charger Aero 7A

The Pneumatic Gun Charger Aero 7A is powered by compressed air or gas supplied from a storage cylinder. The charger is controlled by a solenoid control valve.



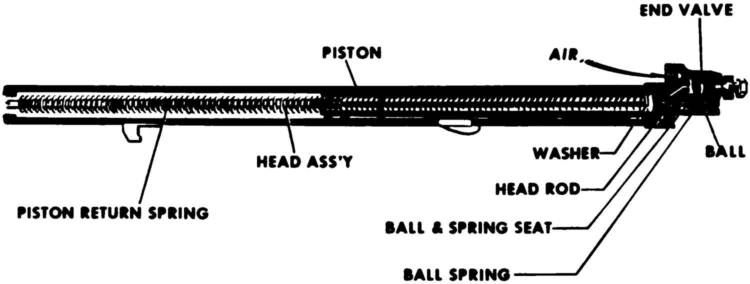


Figure 3–35.—Pneumatic Charger Aero 7A.

When the solenoid is energized, pressurized air or gas is passed through the control valve to the charger, forcing the piston to the rear against the force of the piston return spring (fig. 3–35). Action of the charger is similar to that of the hydraulically operated charger—the piston has a protruding shoulder or driving lug which engages the breechblock slide, thus charging the gun as the piston is moved to the rear. As long as pressure is maintained on the piston, the charger will remain in the recoil or SAFE position. When the pressure is allowed to drop, the piston is returned to the battery position by the piston return spring.

MAINTENANCE

Careful inspection of component parts and close observation of actions are necessary to insure proper performance of the weapon. The items to be inspected and serviced at scheduled intervals are listed below; for detailed instructions, refer to OP 1934.

DAILY OR BEFORE-OPERATING SCHEDULE:

Item	*Maintenance*
Barrel	Check for corrosion and fouling.
Receiver	Check for corrosion and cleanliness.

Item	*Maintenance*
Magazine slide assembly	Check alignment of engraved lines on magazine slide and receiver. Check operation of magazine latch.
Magazine slide anchor	Check for tightness of nuts.
Feed Mechanism AN-M2	Check for corrosion and cleanliness.
Trigger	Check for operation.
Charger	Check for corrosion and cleanliness. Check for operation by actuating charger.

AFTER-FIRING SCHEDULE:

Item	*Maintenance*
Barrel	Clean and lubricate.
Breechblock	Remove, disassemble, and check parts for damage.
Gas mechanism	Clean and inspect fouling of vent plug and damaged parts.
Feed Mechanism AN-M2	Clean and check parts for damage.
Trigger	Inspect for damaged parts.
Gun mechanism in general	Inspect for broken or damaged parts.

The following precautions should be observed when cleaning, lubricating, and working on the gun:

Lubricating oil must be applied sparingly, leaving only a thin film on any working part.

While working on the gun, place it in a supported position so that it will not fall.

If the gun is to be disassembled, be sure that the breechblock is in battery position to minimize the tension on the driving spring.

Clean each gun separately so that the entire gun will be reassembled with its original components.

Never leave ends of cotter pins and locking wires exposed.

Observe fire regulations when handling inflammable materials.

Clean and lubricate the weapon after 600 rounds of firing, when additional rounds are to be fired the same day.

Continual use of dry-cleaning solvent without gloves will dry the skin and may cause minor irritation. If this occurs, rub grease or oil into the skin to replace the natural oils.

Special Tools

A set of tools is provided for disassembly, assembly, cleaning, and preserving the weapon. In addition to the tools described below, there are several other common hand tools which are designed for general use with the M3 gun. For a complete list of these tools, refer to NAVORD List No. 22850 or OP 1934.

The BREECHBLOCK UNLOCKING TOOL (fig. 3–36) is provided for unlocking and removing the breechblock from the receiver. This lever with two arms pivoted at one end is designed to be placed on top of the breechblock bolt in the receiver. The hook on one arm engages the front face of the right breechblock slide so that when the lever is operated, the slides are forced rearward to unlock the breechblock.

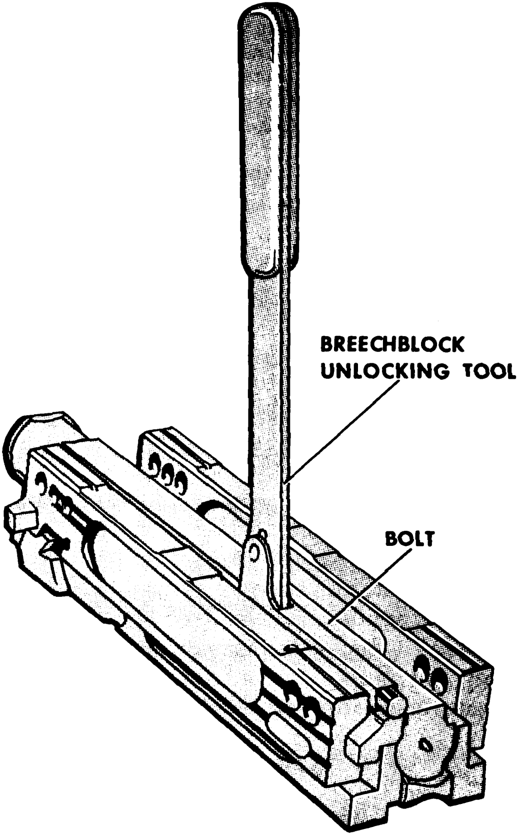


Figure 3–36.—Breechblock unlocking tool.

The **breechblock assembling tool** (fig. 3–37) is used to install the breechblock in the receiver. This tool is U-shaped and designed to fit over the rear end of the breechblock. It holds the breechblock lock in the upper (unlocked) position.

The **sear block assembling tool** (fig. 3–38) is used in the disassembly and assembly of the sear mechanism. This tool is similar in operation to an ordinary vise. Turning the handle controls the compression of the sear buffer springs located in the sear block.

The **sear buffer spring retaining tool** (fig. 3–38) is used in the disassembly and assembly of the sear mechanism. It is also used in the removal and installation of the sear mechanism. This tool is a rod with a handle on one end. The other end engages the grooves of the sear buffer spring plungers when the plungers are in the sear block.

The **driving spring assembling tool** (fig. 3–38) is used in removing the driving spring and installing it in the receiver. This tool is a steel rod with a split stud at one end. The studded end is inserted through the driving spring guide into the hole in the outer end of the driving spring guide plunger.

The **rear buffer wrench** (fig. 3–38) provides a means of removing and installing the driving spring guide sleeve assembly in the rear buffer housing. One face of this tool has a hexagonal socket to fit the driving spring guide head.

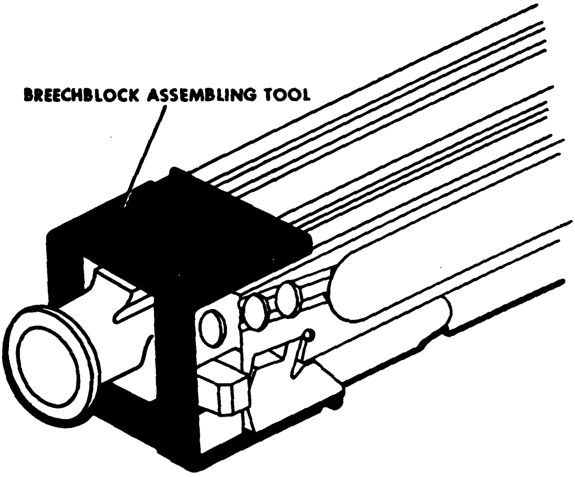
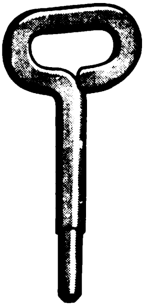


Figure 3–37.—Breechblock assembling tool.

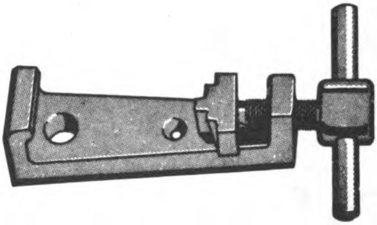
REAR BUFFER WRENCH

REAR BUFFER WRENCH HANDLE



SEAR BUFFER SPRING
RETAINING TOOL

DRIVING SPRING ASSEMBLING TOOL



SEAR BLOCK ASSEMBLING TOOL

Figure 3–38.—Other special tools.

Misfire

Any stoppage must be considered a misfire when the receiver is not visible or where the breechblock is in battery with a round in the chamber.

PROCEDURE.—Upon occurrence of a misfire, proceed as follows under the applicable conditions:

1. When ground testing, wait 30 seconds from the time of occurrence and recharge the gun. Immediately immerse the round in water and remove the round from the vicinity of personnel and aircraft.

Caution: If the gun is hot and the round cannot be removed, the breechblock should be closed and kept in battery position until the hand can be placed on the barrel without discomfort.

2. When airborne, wait 30 seconds from the time of occurrence of the misfire then recharge. If the weapon fails to recharge, no corrective action is possible. Repeated attempts to recharge the gun should be avoided.

NOTE: The possibility of hangfire more than 30 seconds after a misfire is remote. However, if the barrel is hot, the possibility of a "cook-off" increases with the length of time the round remains in the chamber. The safest time to remove a misfire is between 30 and 45 seconds after its occurrence.

CAUSES.—Failure of a chambered round to fire may be caused by:

1. Defective ammunition.
2. Defective firing pin.
3. Weak or broken driving spring.
4. Improper breechblock action.
5. Charger lug impairing the forward movement of the breechblock slides.

REMEDIES.—To correct the weapon's failure to fire a chambered round, proceed as follows:

1. After the aircraft has landed, extract and examine the round. If the primer is deeply indented, treat the round as a misfire.

2. If the primer is not indented or only slightly indented, examine the firing pin for cracks or breakage and replace it if necessary.

3. Examine the driving spring for breakage or permanent set and replace it if necessary.

4. Examine the breechblock slides, the slide springs, and the receiver for any foreign matter or burrs which would interfere with the slides in their forward motion.

5. Check installation and operation of the charger. Replace charger if not operating freely.

Failure To Feed

Failure of continued round feeding may be caused by any one or a combination of the following conditions:

1. Misalignment of magazine slide and receiver.
2. Loose or broken magazine slide anchor parts.
3. Deformed or burred feed mouth.
4. Excessive friction, causing binding in the feed mechanism.
5. Broken or jammed ammunition belt in the ammunition box or feed chute.
6. Link jam in link chute.
7. Insufficient recoil of the breechblock.
8. Loss of tension of the feed mechanism driving spring.

Remedies.—To correct the weapon's failure to properly feed a round of ammunition, proceed as follows:

1. Adjust the magazine slide anchor nuts so that the engraved lines on the receiver align with the engraved lines of the magazine slide. This adjustment must be made when the gun is cold.

2. Tighten the loose components and replace the broken components of the magazine slide anchor.

3. Remove all burrs from the feed mouth, using an oilstone or crocus cloth. If mouth is deformed, replace the feed mechanism.

4. Clean and lubricate the feed mechanism if friction hinders movement of the operating parts.

5. Replace any defective links, rounds, or feed chutes. Calibrate the replaced rounds to insure that the distance from the base of the cartridge case to the rear edge of the double loop link is 2$\frac{9}{32}$ inches.

6. Remove any defective or jammed link in the link chutes. Use caution in removing a jammed link from the feed chute adapter. Do not insert a finger into the adapter.

7. Check the operation of the gas mechanism components. If the piston or gas bracket is dirty, clean and reassemble the parts. Also, remove any burrs from the piston with an oilstone or crocus cloth, prior to reassembling. Deformed or broken parts should be replaced. Also remove all burrs from the interior or exterior surfaces of the breechblock assembly and the interior surfaces of the receiver.

8. Measure with a torque wrench the tension of the feed mechanism driving spring; it should be between 23 and 27 pound-feet.

Failure To Extract

Extraction failure is evident by the breechblock remaining in battery, with a spent cartridge case in the chamber, or by the jamming of a fresh round against the spent cartridge case in the chamber.

Causes.—The chief causes of extraction failures are:

1. Broken extractor parts.
2. Dirty or roughened chamber walls.
3. Ammunition not properly lubricated.

Remedies.—To correct the weapon's failure to extract, proceed as follows:

1. Generally, extraction failures can be remedied by charging the gun, unless the extractor, extractor spring, or extractor pin are broken. When this occurs, the empty cartridge case should be removed from the chamber by inserting a wooden rod into the muzzle end of the barrel and pushing against the cartridge case. Replace any broken extractor part.

2. A dirty chamber with a roughened or carbon-ringed wall will cause a binding or seizing of the empty cartridge case. When the extractor grips the cartridge case, as the breechblock opens, it will rupture the cartridge case, leaving a part of it still in the chamber. The breechblock will pick up another round and jam it against the empty case, causing the gun to cease firing. Remove the new round and push the ruptured cartridge case from the chamber. If the jammed round is broken, remove all brass chips or powder from the receiver and clean and lubricate the area. Examine the chamber for any foreign material or surface roughness on the walls and clean or replace the barrel.

3. Check to see that the ammunition belts are lubricated

with a low-temperature oil. Remove dirt or foreign matter adhering to the belts.

Failure To Eject

Faulty ejection of an empty case may result in jamming of the gun.

CAUSES.—The chief causes of ejection failure are:

1. Broken or deformed ejector.
2. Broken or deformed extractor components.

REMEDIES.—To correct faulty ejection, proceed as follows:

1. Examine the magazine slide assembly for a broken or deformed ejector or ejector stud. Replace if necessary.
2. Examine the breechblock assembly for a broken or deformed extractor, extractor spring, or extractor pin. Replace if necessary.

Runaway Gun

A runaway gun continues firing after release of the firing switch or control for energizing the electric trigger. A runaway gun may be stopped by placing the charger selector switch in SAFE position.

CAUSES.—The chief cause of a runaway gun are:

1. Defective firing switch or electric trigger control.
2. Faulty sear mechanism.

REMEDIES.—To correct a runaway gun, proceed as follows:

1. Replace firing switch or electric trigger control.
2. Examine the sear for deformation or breakage and the sear springs for breakage or permanent set. Replace if necessary.

Slow-Firing Gun

A slow-firing gun will fire at a rate below 650 rounds per minute.

CAUSES.—The chief causes of a slow-firing gun are:

1. Weak or broken driving spring or buffer springs.
2. Sluggish breechblock action.
3. Fouling of gas bracket vent plug or gas port in barrel.

REMEDIES.—To correct a slow-firing gun, proceed as follows:

1. Examine driving spring and buffer springs for breakage or permanent set. Replace if necessary.

2. Examine the breechblock, the interior of the receiver, and the receiver slides for the presence of dirt or excessive lubrication.
3. Clean the air passage of the gas bracket vent plug and the gun barrel gas port.

Clearance of the 20-mm M3 Gun

1. Gas port, 0.152 to 0.156 inch. Use #22 drill or #16 gage wire to check and clean.

2. Gas cylinder vent plug hole, 0.086 inch. Use #45 or #46 drill to check and clean.

3. Push rods and yoke of gas cylinder sleeve, 0.068 inch maximum (group must not vary over 0.003 inch). Check with feeler gage with breechblock in forward position.

4. Head clearance (headspace), 0 to 0.010 inch. Use feeler gage to check between foremost surface of the breechblock bolt body and the rear end of the barrel. For positive clearance the driving spring must be removed.

5. Firing pin hole, 0.152 to 0.156 inch. Use #22 drill or #16 gage wire to check and clean.

6. Breechblock lock and bolt body, 0.001 to 0.005 inch. Check with feeler gage.

7. Driving spring, 27.25 to 30 inches. Remove from gun and measure. Spring pressure when compressed is 112 pounds.

8. All other springs. Measure old springs and new springs (allow ten percent set).

9. Receiver and receiver slides, 0 to 0.0010 inch. Check with feeler gage. (To alter clearance loosen slide bolts and tap forward.)

Note: Headspace and timing are not adjustable on the M3 gun, but headspace can be altered by replacing breechblock lock, locking key, or gun barrel.

20-MM GUN MK 12 MOD 0

General Description

The components of the Mk 12 Mod 0 20-mm gun are: GUN BARREL ASSEMBLY, GUN MECHANISM ASSEMBLY, RECOIL MECHANISM ASSEMBLY, RECEIVER ASSEMBLY, BREECHBLOCK ASSEMBLY, CHARGER ASSEMBLY, GAS MECHANISM ASSEMBLY, BUFFER ASSEMBLY, and the SYNCHRONIZING SWITCH.

Assembly arrangement.—The gun mechanism is supported on the mountings provided within the aircraft. These mountings provide for recoil and counterrecoil movements of the mechanism. The gun is secured to the mounts by trunnions on the recoil mechanism housing. This is the only component of the gun which does not move in recoil.

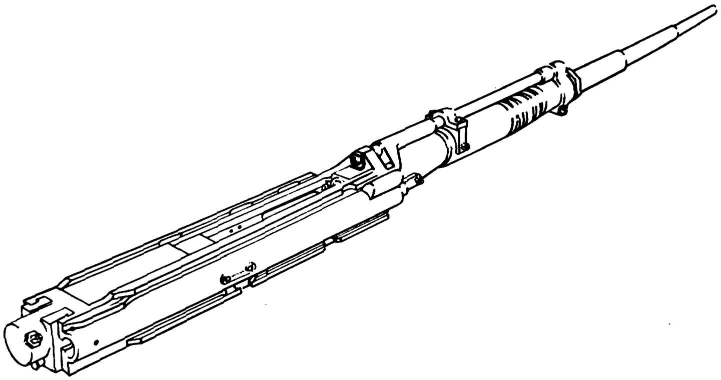


Figure 3–39.—20-mm gun Mk 12 Mod 0.

Design features.—The Mk 12 Mod 0 gun features a combination of blowback and gas operation to open the breechblock. The breechblock is opened by blowback and unlocked by gas operation. It is returned to the closed position by a pneumatic buffer at the rear of the receiver. The gun is automatically-electrically fired, and continues to fire as long as the firing circuit is closed and ammunition is available.

Description of Components

Gun barrel.—The Mk 12 Mod 0 gun barrel (Mk 11 Mod 2) is a tubular alloy steel forging. The barrel is attached to the receiver of the gun by the threads on the breech end of the barrel, and is secured to the receiver by a locking pin which prevents rotation of the barrel after installation. The breech end of the gun is internally machined to form a chamber the shape of the cartridge. The rifling grooves in the bore extend from just forward of the chamber to the muzzle. The rifling is interrupted in only one place along the entire bore. This is the location of the gas port which is drilled through the top of the barrel.

The exterior of the barrel is tapered in steps from the breech to the muzzle. An external thread is machined near the center of the gun for attaching the gas bracket and retaining the recoil mechanism. An external thread is machined at the muzzle to receive a muzzle mount.

GUN MECHANISM.—The gun mechanism includes all the elements for chambering a round, closing and opening the breech, extracting the empty cases, and controlling recoil and counterrecoil actions. It consists of the RECOIL MECHANISM ASSEMBLY, RECEIVER ASSEMBLY, BREECHBLOCK ASSEMBLY, CHARGER ASSEMBLY, GAS MECHANISM ASSEMBLY, and the BUFFER ASSEMBLY. The receiver is the principal structural element of the gun and houses and acts as a guide for the reciprocating breechblock and charger. The charger is on the right side of the receiver and actuates the breechblock for first round loading and safetying actions. The gas mechanism (attached to the gun) actuates the breechblock slides to unlock the bolt after firing. The buffer is mounted on the rear of the receiver, and its function is to return the breechblock toward the locked position.

RECOIL MECHANISM ASSEMBLY.—The recoil mechanism (fig. 3–40) is a spring unit which checks the recoiling parts of the gun mechanism and returns them to battery. The arrangement consists of TWO SPRING ASSEMBLIES, an EXTERNAL FLAT HELICAL RECOIL SPRING attached between a front and rear seat, and a SPACER at the rear of the rear seat. During recoil, the front seat is moved rearward compressing the recoil spring. As the recoil spring is compressed, it moves the rear seat and spacer back along the barrel to push against the RING SPRING in the recoil housing.

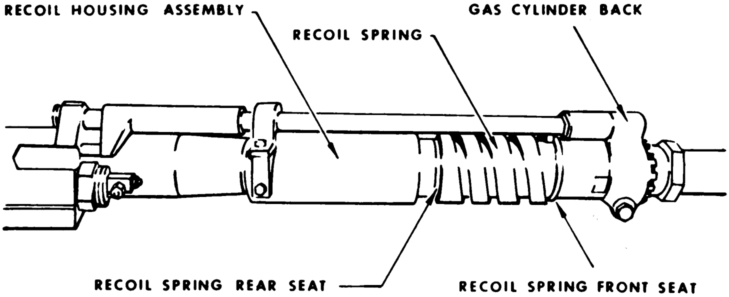


Figure 3–40.—Recoil mechanism.

Recoil housing assembly.—The recoil housing is a cylindrical steel tube concentric with the gun barrel. It is secured to the aircraft mount by horizontal cylindrical trunnions at its rear. The **ring spring** (refer to fig. 3–7) is an arrangement of internal and external rings which form a "bellows-type" spring. During recoil, these rings are forced together causing alternate compression and tension of the V-shaped (cross section) rings. These ring springs are held in position by followers mounted forward and aft in the housing. They absorb the final recoil movement of the gun. The rear follower functions as a spring seat in recoil, and in counterrecoil it transmits the counterrecoil forces from the gun barrel shoulder to the ring springs. The sleeve is an externally threaded cylinder that screws into the rear of the housing. It positions and retains the ring springs in the housing.

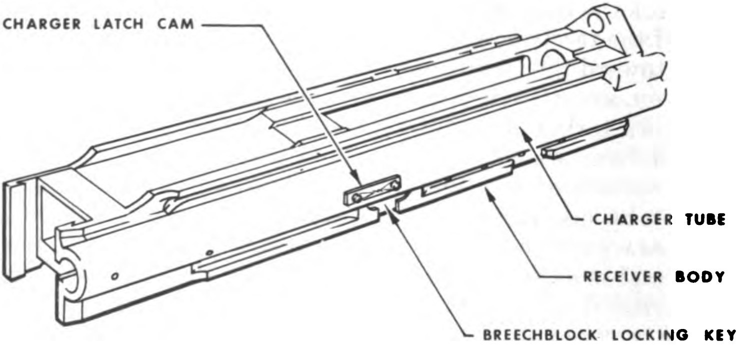


Figure 3–41.—Receiver assembly.

Receiver body.—The receiver houses or supports all working parts of the gun mechanism, and provides attaching surfaces for the feed mechanism. The receiver body is a hollow, rectangular-shaped member, partially open at the top and bottom and completely open at the rear. It is threaded to receive the barrel. At the front on top is a threaded hole for attachment of the gas mechanism sleeve guide. (See fig. 3–41.) The breechblock locking key is mounted in oval-shaped transverse slots in the sides of the body just aft of the ejection slot. The synchronizing switch is mounted on a machined flat on the left forward side of the body. There is a longitudinal cylinder (bored in the right side of the body) which houses the gun charger assembly. At the rear of the body are two dovetailed slots for attaching the buffer.

The RECEIVER PLATE is a machined rectangular part attached to the bottom rear of the receiver to provide a sliding surface for the breechblock.

The RECEIVER SLIDES are thin plates bolted to the inner forward sides of the receiver body. They guide and support the breechblock in conjunction with the receiver plate and the breechblock locking key. A protruding cam at the rear of each slide assists in forcing the breechblock lock down as it nears the battery position. (See fig. 3–42.)

The BREECHBLOCK LOCKING KEY is a solid metal block that fits into the slots in either side of the receiver body. A retaining plate holds the key in place. This key provides a bearing surface for the breechblock lock during firing.

The GAS CYLINDER SLEEVE GUIDE is a cylindrical rod fastened to the lug on top and in the forward end of the receiver. Its function is to guide the gas cylinder sleeve.

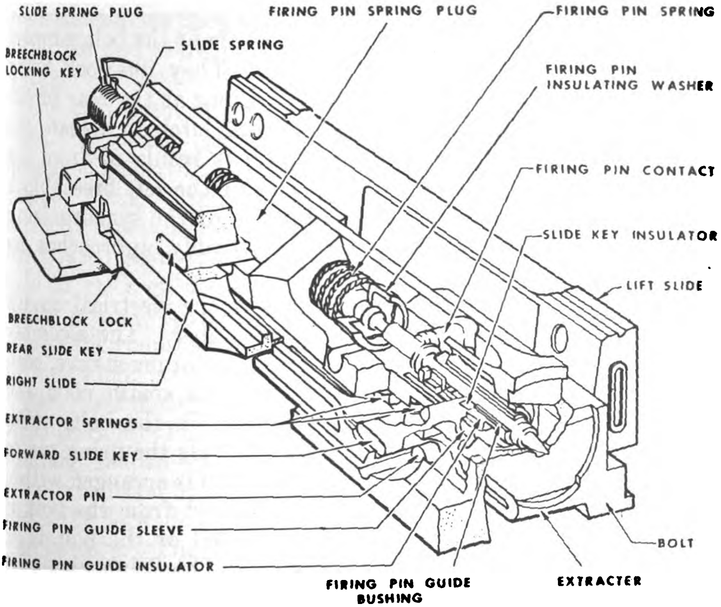


Figure 3–42.—Breechblock assembly, firing pin section.

Breechblock.—The breechblock is the reciprocating assembly that loads a round into the gun, closes the breech, fires the round, and removes the empty case. Its component parts are the **bolt**, **breechblock slides**, **firing pin assembly**, **extractor**, and the **breechblock lock.**

The **bolt** is the main component of the breechblock. It closes the breech when firing and houses the firing pin assembly. Two horizontal slots are milled in the bolt (one forward and the other halfway aft) to provide an opening for assembly of the forward and aft slide keys. These slots are elongated to provide movement (forward and aft) during the locking and unlocking of the breechblock. The firing pin, slide spring, and slide spring plug are contained in a central hole drilled the length of the bolt. A taper in this hole is provided near the forward end to permit protrusion of the firing pin tip. Two long shoulders, one on each side of the bottom of the bolt, form bearing surfaces for the breechblock assembly. A machined surface in the bottom of the bolt provides a pivot for the breechblock lock. The left side is grooved at the forward end to receive the firing pin contact wire.

Breechblock slides, one on each side of the bolt, support and guide the bolt in the receiver. They interlock firing and breechblock locking actions. A lug at the rear of the right-hand slide contacts the charger latch to actuate the breechblock. A contact wire which is insulated from the slide is located on the forward end of the left breechblock slide. This wire contacts two prongs of the synchronizing switch as the breechblock slide assembly approaches its battery position.

The **firing pin assembly** completes the electrical circuit for discharging the round in the chamber. The assembly consists of a **firing pin**, **guide bushings**, **guide sleeve**, **contact**, **guide insulator**, **insulating washer**, **spring plug**, and **spring.** These components are housed in the bolt. (See fig. 3–43.) The firing pin contact connects the firing pin to the synchronizing switch. The firing pin is arranged within the bolt so that it is electrically insulated from the bolt at such times as the firing pin is retracted or the bolt is in battery with a round in the chamber. The firing pin is retracted by the forward slide key. The key extends between the breechblock slides, as previously explained, through the

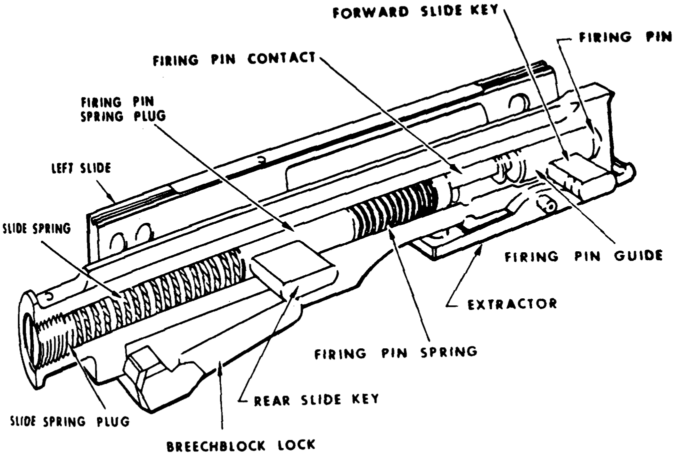


Figure 3–43.—Breechblock assembly, bolt section.

guide sleeve and bushing. When the slides are moved rearward by the gas mechanism, the guide sleeve and bushing carry the firing pin to a retracted position. The breechblock slides move forward on return to battery, releasing the firing pin and allowing it to be extended by the firing pin spring.

The EXTRACTOR is pivoted at the bottom of the breechblock. In normal operation it aids in positioning the round during chambering, and assists in ejecting a fired round (empty case). During clearing of a misfired round, the extractor removes the round from the chamber as the breechblock is moved to the rear by the charger. The extractor is held in place on the bolt by a pin through the bolt and a volute (spiral) spring. This spring pivots the extractor to engage the round and to protect the extractor lips when hit by the round.

The BREECHBLOCK LOCK is rectangular, flat, and of thin cross section. The forward edge is rounded to fit into a similarly shaped slot in the rear underside of the bolt. There are two cams on the lock which engage the receiver cams and force the lock down as the bolt assembly comes forward into battery. The breechblock lock is then held in place by the rear of the breechblock slides bearing down on the top of the lock lugs.

CHARGER.—The charger is a pneumatic mechanism which provides power operation of the breechblock for loading the first round or safetying the gun. The charger piston is actuated by compressed air from the aircraft. Its operating pressure is 1,000 p. s. i. The components of the charger are the CHARGER TUBE, PISTON, RAM HEAD, and a DUMPING VALVE. The entire assembly is housed in the charger tube on the side of the receiver. (See fig. 3–41.) The forward end of the charger tube fits into the charger housing. Six holes are drilled near the rear of the tube to provide air inlets to the piston tube. (See fig. 3–44.) Compressed air is passed into the rear of the piston tube through an air hose connected to the charger housing. O-rings seal both ends of the charger tube to prevent escape of the compressed air. The dumping valve assembly is screwed into the forward end of the tube.

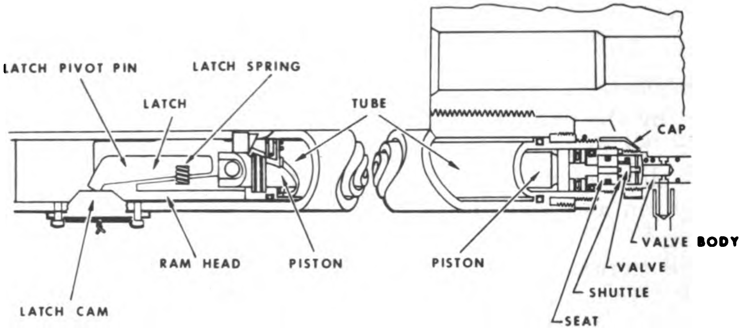


Figure 3–44.—Charger.

The PISTON consists of a hollow tube with a head at the forward end and a ram head at the other end. As the piston is actuated by compressed air, the ram head at the other end of the piston tube engages a lug on the right-hand breechblock slide. This action charges the gun. A lug on the bottom of the ram head rides in a groove inside the charger housing to prevent rotation of the piston and the ram head.

The DUMPING VALVE is located in the forward end of the charger tube, and releases the trapped air in front of the piston so that the piston is able to move forward on its return stroke. The valve assembly consists of a NYLON VALVE SEAT, a VALVE, and a SHUTTLE. As compressed air is admitted to the cylinder (tube) to drive the piston rearward, the valve and shuttle are also forced to the rear. This allows air to enter the forward end of the charger housing, and the shuttle seats against the valve seat to prevent air from escaping. When the pressure is cut off, the pressure trapped behind the piston moves the piston forward. Air trapped in front of the piston moves the valve and shuttle forward to close off the air inlet and open the forward chamber to the outside air.

GAS MECHANISM.—The gas mechanism unlocks the breechblock and starts it to the rear immediately after a round has been fired. The gas bracket nut secures the gas bracket assembly to the shoulder of the gun barrel. A key fitting into slots in the bottom of the bracket and the gun barrel secures the bracket in its proper angular position on the barrel. The bracket nut is also locked by the same key. The cylinder extension of the bracket guides and supports the piston end of the gas cylinder sleeve assembly. The piston and piston ring form a gas seal between the sliding sleeve and the chamber of the gas bracket. This action insures full effect of the gas pressure admitted through the vent plug. (Refer to fig. 3-13.) The rear of the sleeve assembly is directed by the guide attached to the top forward end of the receiver. This guide also acts as a stop for the gas cylinder sleeve spring. As the sleeve is forced to the rear by the gas pressure, it contacts a push rod on either side of the receiver. These push rods are aligned with the breechblock slides and unlock the breechblock as they are forced to the rear by the gas cylinder sleeve.

A forged housing with a hollow cylinder extending towards the rear top side forms the GAS BRACKET. The VENT PLUG is attached to a drilled and tapped hole in the upper part of this hollow cylinder. The drilled gas hole in the barrel is situated directly under the hollow cylinder of the gas bracket. The vent plug is cylindrical and is drilled to permit passage of the necessary gas pressure for breechblock unlocking.

The GAS CYLINDER SLEEVE acts as a piston and piston rod and extends between the gas bracket and the guide mounted on the receiver. (Refer to fig. 3-13.) The piston end of the sleeve in the gas bracket is actuated by the firing gases to move the sleeve rearward. Two arms at the rear of the sleeve contact push rods which move the breechblock slides. This arm action unlocks the breechblock and starts it moving rearward.

The GAS CYLINDER GUIDE is a short cylinder attached to the receiver which guides the sleeve. The sleeve spring exerts pressure against the face of the guide. A three-wire, twisted-strand spring (sleeve spring) fits inside the sleeve and exerts pressure against the sleeve guide to force the sleeve forward.

BUFFER ASSEMBLY.—The buffer assembly is pneumatically operated. Its function is to absorb the force of the rearward movement of the breechblock, stop this motion, and return the breechblock to battery. It consists of a HOUSING, PISTON, AIR INLET FITTING, CHECK VALVE, and BLEEDER VALVE. Compressed air is admitted to the rear of the piston by the air inlet fitting and the check valve. As the breechblock moves aft and contacts the buffer piston, the check valve closes and traps this air behind the piston. The trapped air is compressed. This retards the rearward motion of the breechblock, and as the breechblock movement is stopped, the trapped air expands and drives the breechblock forward.

The BUFFER HOUSING contains the PISTON, SLEEVE, and CHECK VALVE. Two holes are drilled in the housing to receive the air inlet fitting and the bleeder valve. The entire housing fits into dovetail slots in the rear of the receiver and is secured by a lock plunger. The air inlet fitting and the bleeder valve may be interchanged to make either a right- or left-hand assembly.

An O-ring and two leather backup rings on the BUFFER PISTON make a snug fit of the piston in the buffer housing. The assembly is held in the housing by a sleeve screwed into the front of the housing chamber.

The CHECK VALVE consists of a VALVE SEAT, a BALL, and a SPRING. When the buffer air in the chamber needs replenishing, the ball is unseated by pressure from the aircraft's supply. The ball automatically seats to prevent loss of buffer air when the piston is moved to the rear by the breechblock.

FIRING CIRCUIT.—Figure 3–45 shows the wiring of a single free-firing gun installation. Current from the aircraft supply flows through pin C of the receptacle to squib C of the SYNCHRONIZING SWITCH. When the left breechblock slide nears its locked (battery) position, contact is made through squibs B and C and the bolt contact completes the circuit through squib A.

Figure 3–46 shows two guns wired for synchronized firing

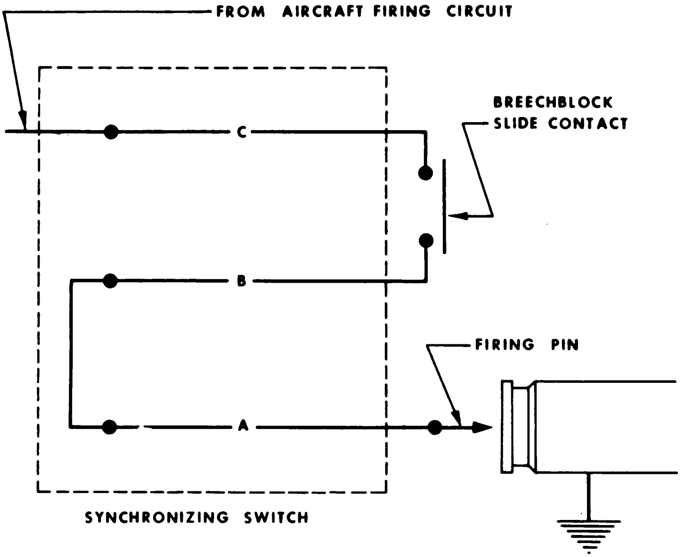


Figure 3–45.—Schematic diagram of firing circuit for single gun.

and free firing of either gun. Current is supplied to squib C of the synchronizing switches of both guns. By moving the breechblock of gun number 2 into battery ahead of gun number 1, the current flows from squib C of gun number 2 through its breechblock slide contact to squib B and then to squib A of the synchronizing switch of gun number 1. The breechblock of gun number 1 then comes forward, and the current supply to its synchronizing switch at squib C is allowed to flow through to squib B. Simultaneously, the bolt contact (breechblock slide contact) completes the circuit to its firing pin from squib B in gun number 2, and the current from squib B in gun number 1 flows through squib A of gun number 2. This allows both guns to fire together.

If there is a jam or other casualty in either gun while firing, the FREE-SYNC switch in the firing circuit should be turned to the FREE position. This permits the current to flow directly through squib A to the firing pin of the usable gun. In this condition, the firing takes place immediately when the firing pin contacts the cartridge primer.

The SYNCHRONIZING SWITCH, shown schematically in figures 3–45 and 3–46, is the Mk 1 Mod 1. It contains three con-

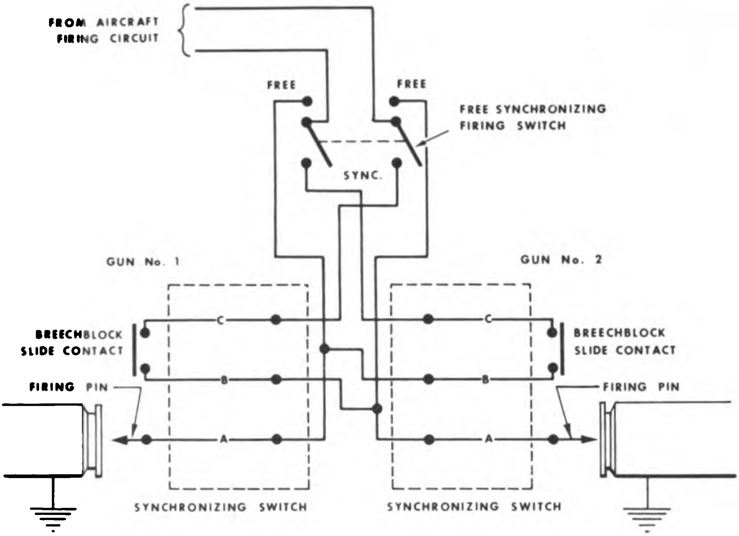

FROM AIRCRAFT FIRING CIRCUIT
FREE
FREE
FREE SYNCHRONIZING FIRING SWITCH
SYNC.
GUN No. 1
GUN No. 2
BREECHBLOCK SLIDE CONTACT
BREECHBLOCK SLIDE CONTACT
FIRING PIN
FIRING PIN
C
B
A
C
B
A
SYNCHRONIZING SWITCH
SYNCHRONIZING SWITCH

Figure 3—46.—Schematic diagram of firing circuit for synchronized guns.

tacts which operate with the breechblock to complete the firing circuit of the guns. Its case is constructed in two halves and bolted together. The assembly contains the A, B, and C SQUIBS, two CONNECTORS, and the CONNECTING WIRES.

20-MM FEED MECHANISM MK 7 MOD 0

General Description

The 20-mm Feed Mechanism Mk 7 Mod 0 is a pneumatically operated device for feeding 20-mm belted ammunition into the Mk 12 type guns. The feed mechanism is driven by an air motor which is supplied with compressed air from the aircraft's air system.

The ammunition links used with this feed mechanism are the Mk 2 Mod 0 together with an end link Mk 2 Mod 1.

The Mk 7 Mod 0 feed mechanism is a pneumatic, reciprocating, piston-type mechanism mounted on the gun receiver body. It is designed to have low profile, light weight, and the ability to sustain a high rate of fire with no adverse load on the gun mechanism, and no adverse effect on the rate of fire. It can be quickly installed and removed, and is so constructed to permit the closest stagger between guns which will allow free passage of ammunition. Both the right-hand and left-hand feeds require identical components. Thus, the components may be interchanged to feed from either side of the feed mechanism.

GENERAL ARRANGEMENT.—The components of the Mk 7 Mod 0 feed mechanism are the COVER AND DRIVE ASSEMBLY with its drive and cover subassemblies, the FEED THROAT ASSEMBLY, and the TIE BAR ASSEMBLY. (See fig. 3–47.)

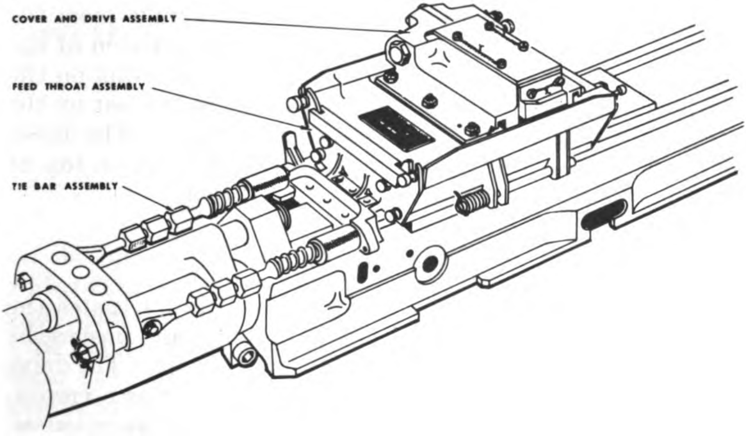


Figure 3–47.—General arrangement of the Mk 7 Mod 0 feed mechanism.

The feed mechanism is secured to the top of the receiver body of the Mk 12 Mod 0 gun by six locking lugs and two tie bar assemblies. The upper section of the feed mechanism is the cover and drive assembly. The drive subassembly is bolted to the top of the cover with three flathead and three roundhead screws. The throat assembly comprises the lower section of the feed mechanism, and is mounted on top of the receiver. Its lower section fits into the receiver body directly above the bolt passageway. The throat supports the STRIPPER SUBASSEMBLY, FORWARD GUIDE SUBASSEMBLY, CAMSHAFT MECHANISM, EJECTOR GROUP, BELT HOLDING PAWL SUBASSEMBLY, and the HOLDING PAWL RELEASE MECHANISM.

The tie bar assembly secures the feed mechanism to the support located forward of the feed mechanism. Each tie bar has a knurled spring-loaded snap lock that fastens it to the two lugs on the forward end of the throat. The forward ends of the tie bars are attached to the forward supports by a bolt and nut arrangement.

The drive subassembly functions to actuate the drive slide, the drive pawls of which engage the ammunition links and drive the ammunition belt into the mechanism. The belt holding pawls retain the ammunition belt in the mechanism as the drive pawls move to engage the link. The LINK GUIDE and T-SHAPED RAIL, which are machined surfaces on the bottom of the cover, direct the ammunition into the stripper subassembly. The stripper removes the links from the ammunition as it moves across the stripper by action of the drive pawls. A BRIDGE on the link supports the link on the stripper. The round is cammed into the feed throat by the stripper and the forward guide cam surfaces. The hold-down pawl which is located in the stripper bears on top of the round when the round is in the feed throat.

Detailed Description

COVER AND DRIVE ASSEMBLY.—This assembly actuates the ammunition belt, guides the links and rounds, and pushes the round into the throat. The cover is a single unit. The drive subassembly contains the DRIVE PISTON, STATIONARY PISTON, BUFFER PLATE, VALVE STEM, VALVE SEAT, SEAR MECHANISM, DRIVE SLIDE SUBASSEMBLY, DRIVE PAWL, LAST ROUND LOCK, and the MOTOR HOUSING. This drive subassembly is powered by an air pressure of 500 p. s. i. minimum during operation, and is mounted on top of the cover assembly. It operates at right angles to the centerline of the gun.

DRIVE PISTON.—The drive piston (fig. 3–48) translates (changes) the force of the compressed air into a reciprocating mechanical action. It is housed in the drive subassembly. It is a steel fabrication with one end bored to fit over the stationary piston. The other end is solid to function as a piston head. An O-ring seals the piston within the cylinder to prevent loss of air pressure. There are five collars machined on the piston (including the two end collars), and the collar on the open end of the piston has a notch that fits a pin on the drive slide subassembly. This notch is engaged to the slide to prevent rotation of the piston. Both collars

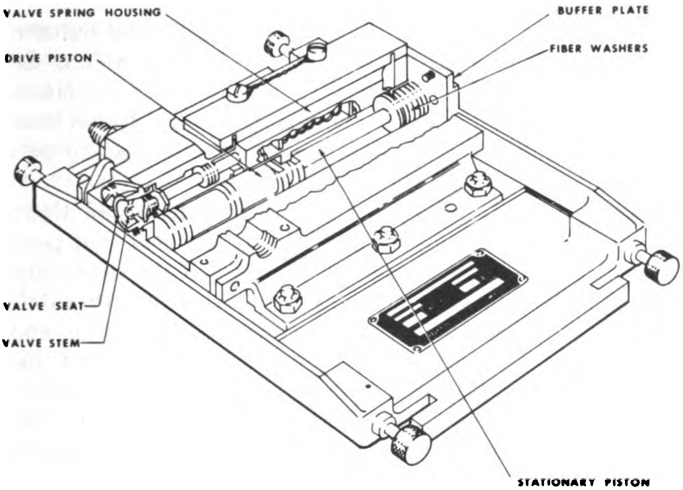


Figure 3–48.—Drive components, top view.

on the open end engage a crescent-shaped shoulder on the slide to transmit the reciprocating action of the piston to the slide subassembly.

STATIONARY PISTON.—This piston is hollow to allow air to enter the inside of the drive piston. This allows the drive piston to be returned at the end of its power stroke. The steel stationary piston is securely fixed by the outer end being retained by the buffer plate, while the inner end rides inside the drive piston. Each end of the stationary piston is fitted with O-rings to insure pressure-tight operation. Three FIBER WASHERS mounted on the tubular end of the buffer plate cushion the drive piston at the end of the power stroke. (See fig. 3–48.)

BUFFER PLATE.—An air passage in the buffer plate directs air pressure through the stationary piston for the return stroke of the drive piston. The buffer plate acts as a support for the stationary piston retainer and the three fiber buffer washers. (See fig. 3–48.)

VALVE STEM.—The valve stem (reciprocating) controls the inlet and exhaust air pressures for the air drive. It is located in the upper part of the housing. The outer end is supported by the valve seat on the drive stroke and by the bore in the housing on the return stroke. The inner end is locked to the valve spring housing. The stem is a machined steel rod fitted with a tapered valve nut on the outer end. On the valve stem adjacent to the valve nut is a four-fluted section. This section provides an air passage from the inlet port to the head of the drive piston. This fluted section also guides the valve stem during the reciprocating action. (See fig. 3–48.)

Valve seat.—During the drive stroke, the inner diameter of the valve seat (fig. 3–48) provides an air seal that permits the air pressure to port over to the head of the drive piston. During the return stroke, the exhaust pressure is ported out through the open end of the valve seat. The outer end of the valve seat is tapered to allow **relief expansion** of the exhaust pressure. The seat is bolted to the housing over the end of the valve stem with the center of the valve seat aligned with the center of the valve stem. The valve seat maintains a pressure seal through an O-ring packing around its outside circumference. (See fig. 3–48.)

Sear mechanism.—The sear mechanism controls the movement of the valve stem. This mechanism contains a **power sear, exhaust sear, sear spring, sear spring pin, valve spring, valve spring housing, two spring seat buttons, two sear pivot pins, sear slide**, and **two bumpers**. Each sear is tripped by a cam projection machined on the top of the sear slide. Two lugs on top of the slide provide anchor points for the valve spring that is mounted inside the valve spring housing. The rectangular-shaped sear slide reciprocates inside the upper section of the motor housing. A lug on the underside of the sear slide engages two collars of the drive piston. Clearance for the passage of the drive piston is provided in the bottom of the sear slide by a concave radial surface in the slide. A projecting shoulder on one side of the housing acts as a stop for the sears. The outer end of the housing is machined to fit the collar end of the valve stem. The valve is operated by the valve spring located within the valve spring housing. (See fig. 3–48.)

There are spring seats at each end of the valve spring which provide a surface for the sear slide lugs to butt against during operation. Each sear is pivoted about its holding pin (pivot) which protrudes through the housing. A pivoted sear spring holds down the extended arm of each sear with a constant pressure. The two interchangeable steel bumpers mounted at each end of the housing have arched cutouts which provide for passage of the valve stem.

DRIVE SLIDE SUBASSEMBLY.—The drive slide subassembly is located at the bottom of the drive housing. It changes the force of the drive piston into a mechanical force to operate the feed mechanism. Its components are the DRIVE SLIDE, DRIVE PAWLS, INERTIA BLOCKS, PLUNGERS, PIVOT PINS, and SPRINGS. (See fig. 3–49.)

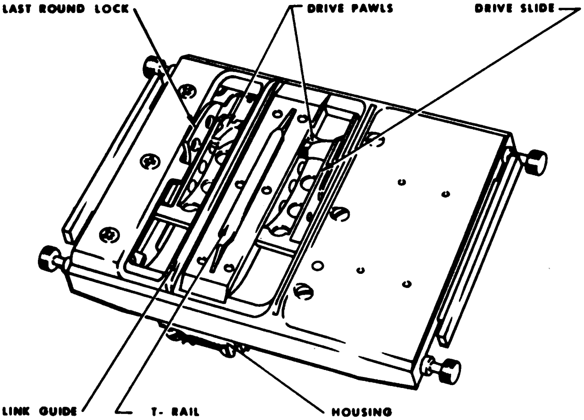


Figure 3–49.—Drive components, bottom view.

The drive slide is connected to the drive piston. It transmits the reciprocating power of the drive piston to the drive pawls on the bottom of the drive slide. The top of the drive slide is grooved to provide clearance for the drive piston. A pin at one end of the grooved section engages the slot in the collar at the open end of the drive piston. Two cutouts on the bottom of the slide are provided for mounting the inertia blocks and drive pawls. One projecting lug on the drive slide acts as a stop for the last round lock mechanism. The other operates the HOLDDOWN cam and its mechanism.

The drive pawls engage the ammunition links and drive the ammunition into the feed mechanism. Each pawl is of different length and shape, and is held in place by pivot pins. The inertia blocks, springs, and plungers are held in place between the drive slide and the forward side of the drive pawls in such a manner as to force the drive pawls back to the driving position at the beginning of each stroke.

The LAST ROUND LOCK stops the feed mechanism when ammunition supply is exhausted. It may be mounted for either right- or left-hand operation. During firing, the last round lock is held out of engagement with the slide lug by the links of the belted ammunition. After the last round has been fired, the spring-loaded plunger pivots downward to engage a lug in the slide, stopping the drive action.

The MOTOR HOUSING is a machined aluminum alloy forging which houses and supports the components of the drive assembly. It is bolted to the cover and bored for the drive piston, stationary piston, valve stem, and air passageways. Its bottom is machined to guide the drive slide, and to provide clearance for the last round lock and forward guide cam. A compartment screwed to the top of the housing encloses the sear mechanism.

The COVER SUBASSEMBLY supports the drive subassembly and guides the links during firing. Four spring-loaded knurled pins lock this assembly to the holes on each end plate of the FEED THROAT assembly. A machined plate is bolted between the drive subassembly and the cover subassembly to provide a smooth surface for the drive slide. The cover itself has two rectangular holes that accommodate the driving components of the AIR MOTOR.

Two machined link guides are riveted to the underside of the cover. The rear guide aligns the links in a fore and aft direction, and the front (T-rail) guide prevents the forward part of the link from dropping down during the firing (cycling) action. (See fig. 3–49.)

FEED THROAT ASSEMBLY.—The feed throat assembly strips the links from the round, guides the round into the ramming position, ejects the empty case from the gun, and holds the ammunition while the drive pawls move to engage another link. This assembly fits on top of the gun receiver body with the lower section of the throat extending into the receiver. Two lugs on the forward end of the assembly secure it to the tie bar assemblies. The link chute and the ammunition feed chute both are secured to the outer sides of the steel end plates.

Components and subassemblies of the feed throat assembly are the THROAT, STRIPPER SUBASSEMBLY, FORWARD GUIDE SUB-

ASSEMBLY, CAMSHAFT MECHANISM, BELT HOLDING PAWL SUBASSEMBLIES, HOLDING PAWL RELEASE MECHANISM, and the EJECTOR GROUP. (See fig. 3–50.)

The THROAT is machined to mount the components and subassemblies of the feed throat assembly. Three lugs on each side of the throat lock the feed mechanism to the receiver body on the gun. The ejector group is mounted on the platform-like extension at the rear of the throat. The lower section of the throat has machined guides which support and position the round for ramming into the gun barrel.

The STRIPPER SUBASSEMBLY (fig. 3–50), along with the T-rail and the guide of the cover, strip the links from the round and guide the round into the lower section of the throat. This assembly also contains the holddown arm, pawl, and its spring and guide as well as their positioning pins. The stripper is secured to the aft machined channel in the throat by a tapered-end setscrew. The holddown arms is splined to the shaft that connects the forward guide and the stripper subassemblies. A pawl is hinged to the upper end of the holddown arm and is spring-loaded by a spring and spring

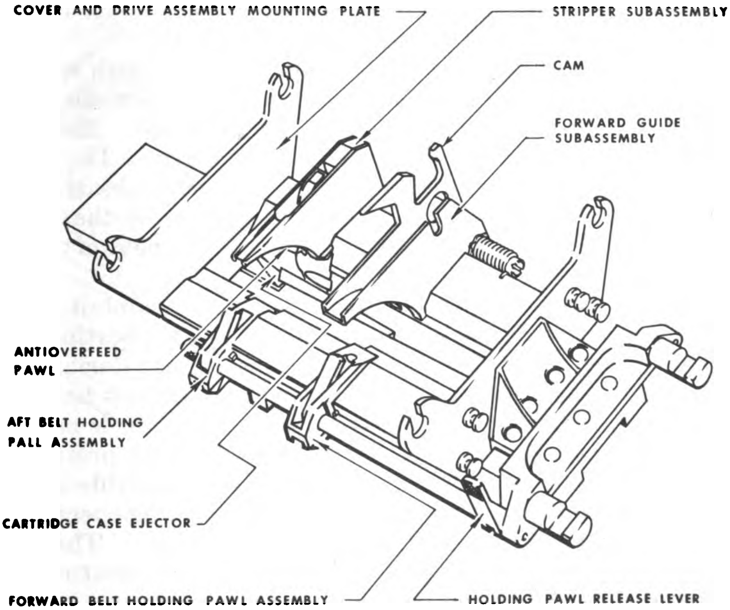

COVER AND DRIVE ASSEMBLY MOUNTING PLATE
STRIPPER SUBASSEMBLY
CAM
FORWARD GUIDE SUBASSEMBLY
ANTIOVERFEED PAWL
AFT BELT HOLDING PALL ASSEMBLY
CARTRIDGE CASE EJECTOR
FORWARD BELT HOLDING PAWL ASSEMBLY
HOLDING PAWL RELEASE LEVER

Figure 3–50.—Feed throat assembly.

guide device fitted in a cutout of the arm. The tapered end of the stripper engages between the round and the raised cutout of the link for the stripping operation. The lower contour of the tapered end of the stripper guides the round into the lower section of the throat. The upper surface and slope end of the stripper guides the stripped link out of the feed mechanism.

The FORWARD GUIDE SUBASSEMBLY guides the round into the feed throat and houses the cam which actuates the holddown arm and pawl. The cam which is actuated by the projecting lug of the drive slide, operates the holddown pawl through the camshaft mechanism. Splined CUTOUTS on the bottom of the cam engage a spline on the forward end of the camshaft. The forward upper section of the cam is shaped like the head of a bird. There is an upright projection at the top rear of the cam which serves as a lever arm (when engaged by the drive slide lug) to pivot the cam backward. This withdraws the stripper pawl and prevents it from interfering with the path of the ammunition. The upper sides of the forward guide have cutouts for mounting the lug of the link ejection chute. These cutouts are on both sides to provide for either right-or left-hand operation. (See fig. 3–50.)

The CAMSHAFT MECHANISM consists of a shaft with splines at both ends, a CAMSHAFT SPRING, a LOCK, and LOCKING PINS. The forward spline engages and positions the cam. The rear spline engages and positions the holddown arm. The camshaft spring forward of the guide subassembly returns the cam to its neutral position when not actuated by the drive slide. The camshaft transmits the motion of the cam to the holddown arm device. (See fig. 3–50.)

The two BELT HOLDING PAWL SUBASSEMBLIES maintain a restraining action on the belted ammunition by supporting the leading unstripped round in the feed mechanism during the cycling (firing) action. The forward and aft belt holding pawls are mounted on brackets in separate channels on top of the throat. Each pawl is spring-loaded and protrudes through its mounting bracket. The brackets provide a riding surface for the ammunition during the feeding operation. As the round moves inward, the pawls are released. They return to their normal position to bear against the next round and prevent its backing out of the feed mechanism.

The holding pawl release mechanism (fig. 3–50) is manually operated to depress the belt holding pawls. This allows the ammunition to be unloaded from the feed mechanism. A release cam is mounted between the holding pawls, and is actuated by a spring-loaded lever located at the forward end of the feed throat. This release mechanism allows the ammunition to be unloaded without removing the cover assembly, provided that the feed mechanism has not been moved through a cycle.

The **EJECTOR GROUP** is located to the rear bottom of the feed throat assembly. After the round has been fired, the empty case is blown out of the barrel chamber by the expanding gases in the barrel. The case moves rearward while engaged in the extractor in the breechblock assembly. The top of the case strikes the fingers of the ejector assembly (fig. 3–50) which stops the rearward movement of the empty case. The ejector springs cushion this contact and cause the empty case to heel around the extractor (be pulled from the extractor in a camming motion), thereby ejecting the case from

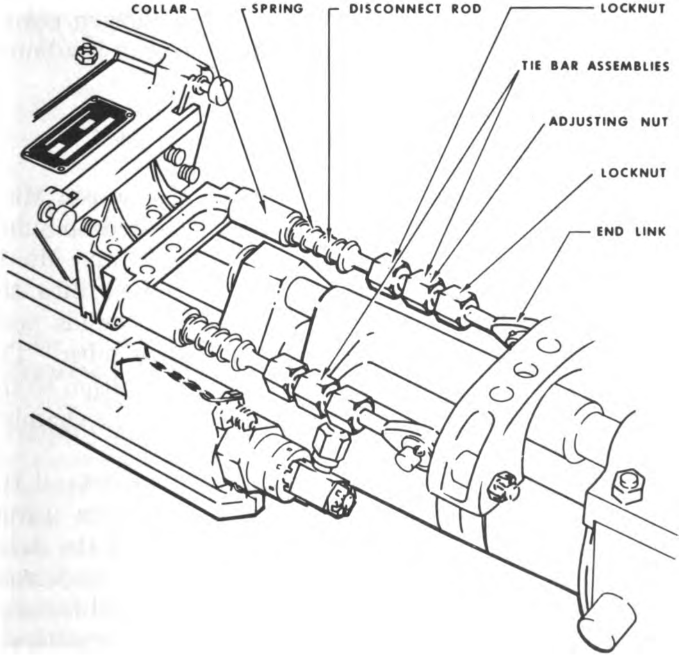


Figure 3–51.—Tie bar assembly.

the gun mechanism. The ejector fits into two keyways which are in a pocket machined in the platform-like extension of the feed throat. The ejector has three drilled holes which contain three springs. These are the springs which cushion the force of the empty case when it is blown against the ejector by the barrel gases.

TIE BAR ASSEMBLY.—The two tie bar assemblies lock and hold the feed mechanism at the proper distance from the nonrecoiling parts of the gun or the structure of the aircraft, as the case may be. Each tie bar assembly is adjustable and contains a DISCONNECT ROD, an END LINK, TWO LOCKNUTS, an ADJUSTING NUT, and a SPRING-LOADED COLLAR. (See fig. 3–51.) One end of each disconnect rod has a U-shaped cutout which mates with the lugs on the front of the feed throat. Spring-loaded collars fit over each lug and lock them in place. The forward ends of the tie bar assemblies are connected by bolts which allow the tie bars to swing away when disconnected from the feed mechanism. One end of each rod and one end of each link are threaded to screw into the threaded locks. These locks may be adjusted to lengthen or shorten the tie bar assemblies. The locks are secured by two hex-head nuts, one on each side of the locks.

Operation

GENERAL OPERATION.—The 20-mm Feed Mechanism Mk 7 Mod 0 is pneumatically powered to supply belted ammunition to a position within the receiver of the 20-mm Mk 12 gun mechanism. Belted ammunition is pulled into the feeder, the rounds stripped of links, and the rounds positioned in the throat for ramming into the gun chamber. The feed mechanism supplies a new round of ammunition to the gun as soon as the preceding round is fed into the chamber of the gun barrel.

DETAILED OPERATION.—It is important to understand the compressed air flow paths in the Mk 12 gun DRIVE MOTOR. Two air flow paths are used for the operation of the drive motor. (See fig. 3–52.) One flows from the INLET PORT through a longitudinal passage in the housing, and through a diagonal passage in the buffer plate. This flow path directs the compressed air through the stationary piston to the inside of the drive piston to actuate the return stroke of the drive piston. The other air flow path is from the inlet port through a vertical passage in the housing to the head end of the drive piston. This path provides the drive stroke power for the drive subassembly.

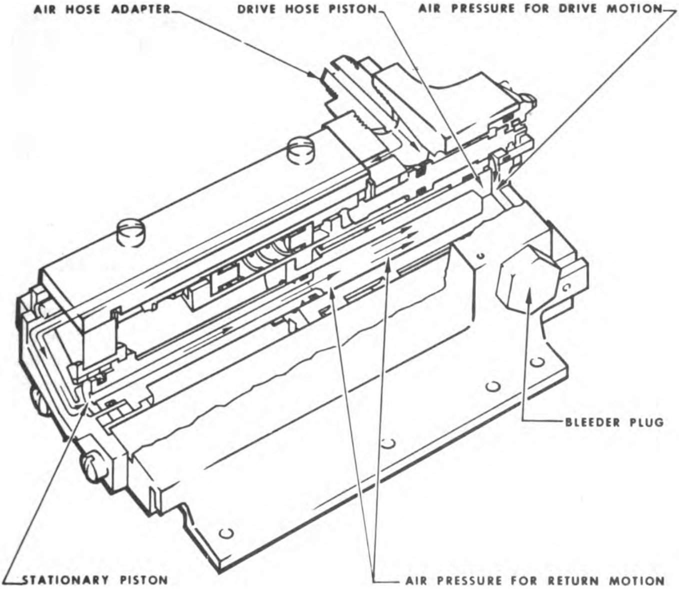


Figure 3–52.—Drive motor pressure flow paths.

The illustrations which follow summarize the mechanical MOVEMENTS OF THE SEAR MECHANISM, the MOVEMENTS OF THE DRIVE SUBASSEMBLY, and the ACTION OF THE FEED MECHANISM in supplying ammunition to the gun and disposing of the empty cases and links. THE NUMBERS (1, 2, 3, etc.) ASSOCIATED WITH THE DESCRIPTIONS OF MECHANISM MOVEMENTS FOUND UNDER EACH OF THE ILLUSTRATIONS WHICH FOLLOW, DO NOT REFER TO PARTS OF THE ILLUSTRATIONS BUT TO THE SEQUENCE OF MOVEMENTS WITHIN THE MECHANISMS. In other words, these numbers merely indicate the SEQUENCE in which the various movements take place.

MOVEMENTS OF THE SEAR MECHANISM.

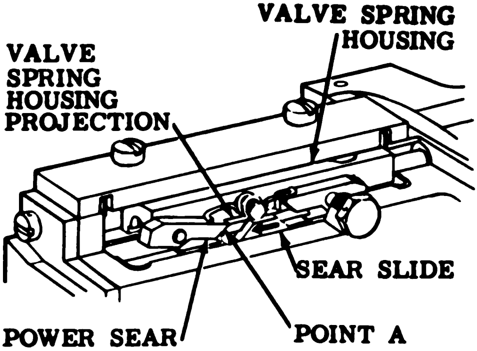


Figure 3–53.—Sear mechanism movement at start of drive stroke.

1. Sear slide moving on drive stroke.
2. Valve spring housing projection held by power sear at point A.

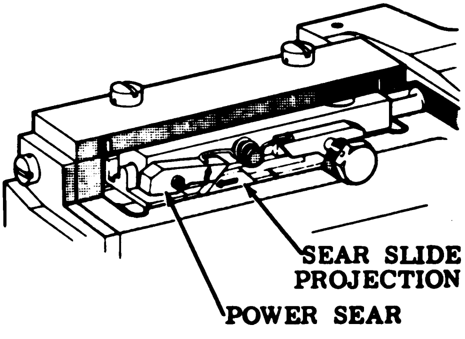


Figure 3–54.—Sear mechanism movement during drive stroke.

1. Sear slide projection raising power sear.

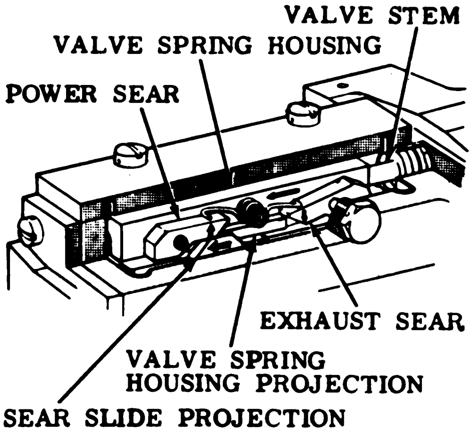


Figure 3–55.—Sear mechanism at end of drive stroke.

1. **Powor sear fully raised by sear slide projection, releasing valve spring housing projection.**
2. **Valve spring housing and connected valve stem shift to exhaust position.**
3. **Exhaust sear pivots downward.**

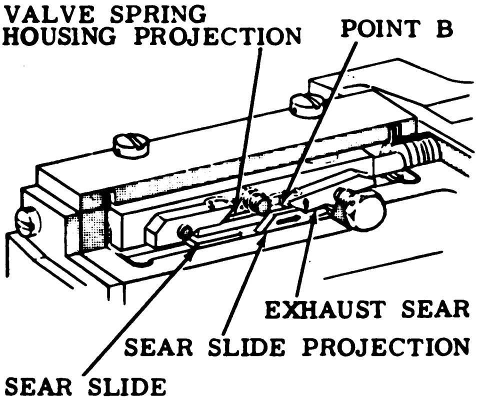


Figure 3–56.—Sear mechanism movement during return stroke.

1. **Sear slide moving on return stroke.**
2. **Sear slide projection raising exhaust sear.**
3. **Valve spring housing projection held by exhaust sear at point B.**

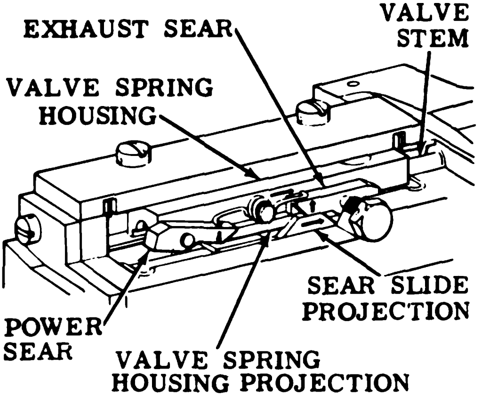


Figure 3–57.—Sear mechanism movement at end of return stroke.

1. **Exhaust sear fully raised by sear slide projection, releasing valve spring housing projection.**
2. **Valve spring housing and connected valve stem shift to drive position.**
3. **Power sear pivots downward.**

MOVEMENTS OF THE DRIVE SUBASSEMBLY.

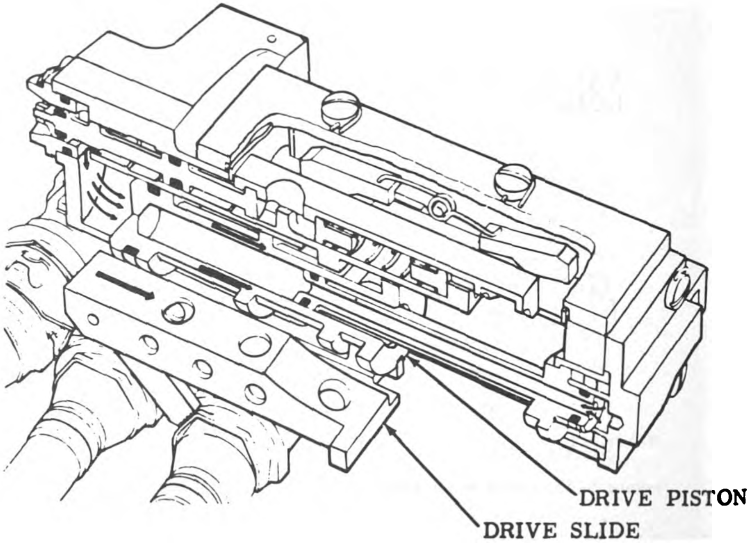


Figure 3–58.—Drive subassembly at start of drive stroke.

1. **Pressure on drive piston head moves drive piston and drive slide.**

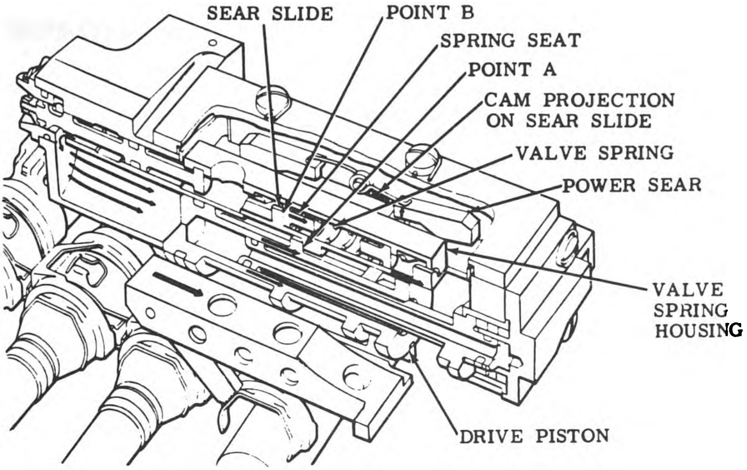


Figure 3–59.—Drive subassembly during drive stroke.

1. Drive piston engages sear slide at point A.
2. Sear slide engages spring seat in valve spring housing at point B, compressing valve spring.
3. Cam projection on sear slide starts to lift power sear.

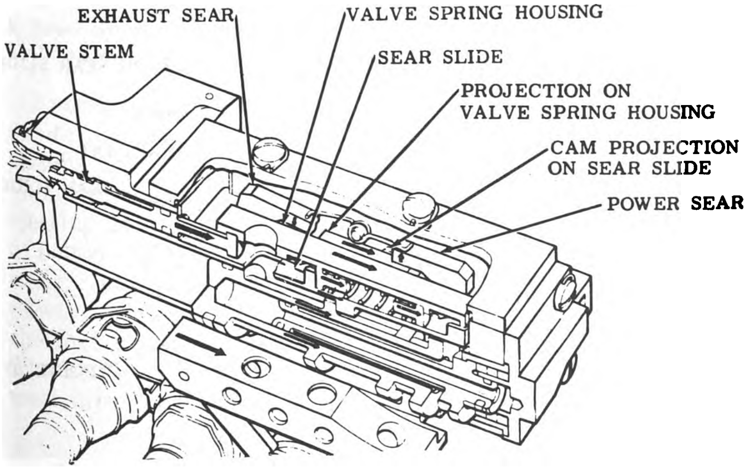

EXHAUST SEAR
VALVE STEM
VALVE SPRING HOUSING
SEAR SLIDE
PROJECTION ON VALVE SPRING HOUSING
CAM PROJECTION ON SEAR SLIDE
POWER SEAR

Figure 3–60.—Drive subassembly at end of drive stroke.

1. Cam projection on sear slide raises power sear.
2. Power sear releases projection on valve spring housing, shifting connected valve stem to exhaust position.
3. Exhaust sear pivots in locking position.
4. Drive pressure exhausted to atmosphere.

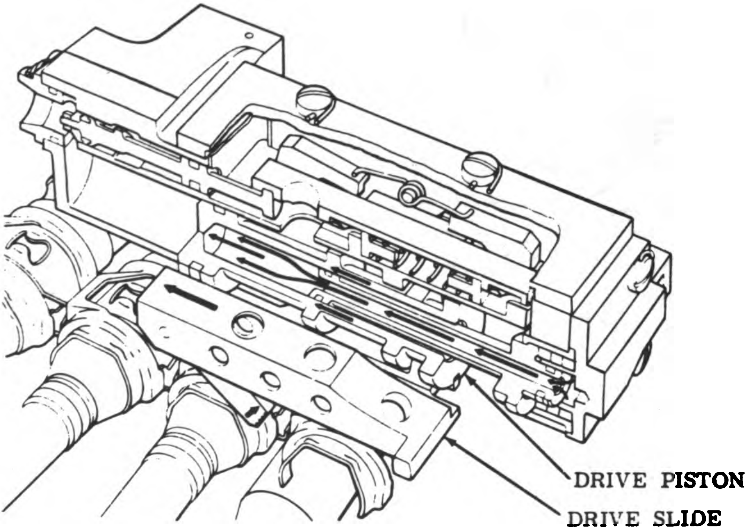


Figure 3–61.—Drive subassembly at start of return stroke.

1. Return pressure moves drive piston and drivo slide.

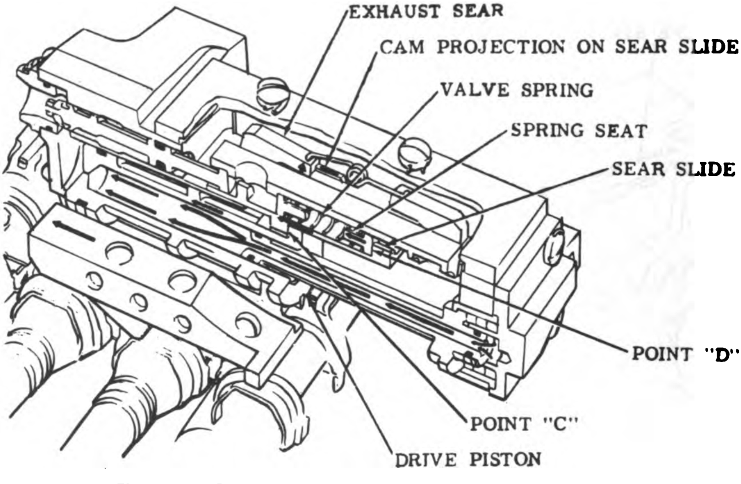


Figure 3–62.—Drive subassembly during return stroke.

1. Drive piston engages sear slide at point C.
2. Sear slide engages spring seat in volve spring housing at point D, compressing the valve spring.
3. Cam projection on sear slide starts to lift exhaust sear.

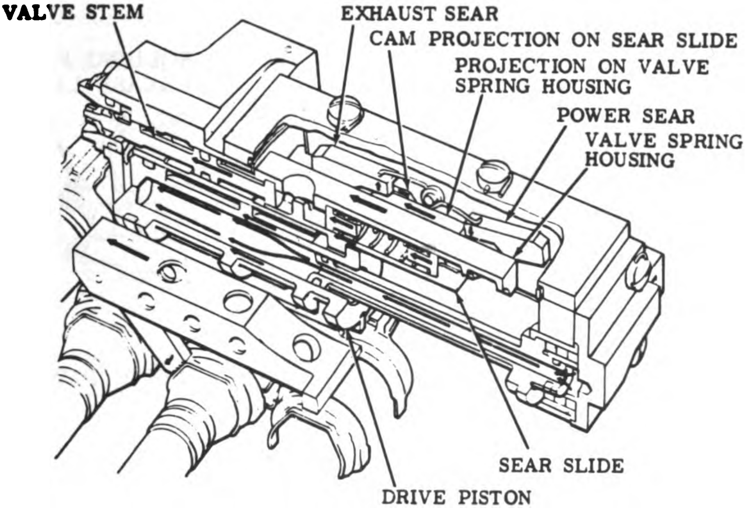


Figure 3–63.—Drive subassembly at end of return stroke.

1. Cam projection on sear slide raises exhaust sear.
2. Exhaust sear releases projection on valve spring housing, shifting connected valve stem to drive position.
3. Power sear pivots to locking position.
4. Drive pressure ported over to piston head.

FEEDER AMMUNITION HANDLING MOVEMENTS.—The movements of feeder ammunition handling concern the cyclic actions of indexing, stripping, driving, and maintaining (holding) the ammunition in the feed throat assembly, and ejecting the empty cases from the gun. The first round of belted ammunition is inserted in the feed mechanism manually. This action depresses the spring-loaded belt holding pawls. These pawls return to their normal position when the first round has cleared the ends of the holding pawls. The first round is then held in position ready for the feed mechanism to operate.

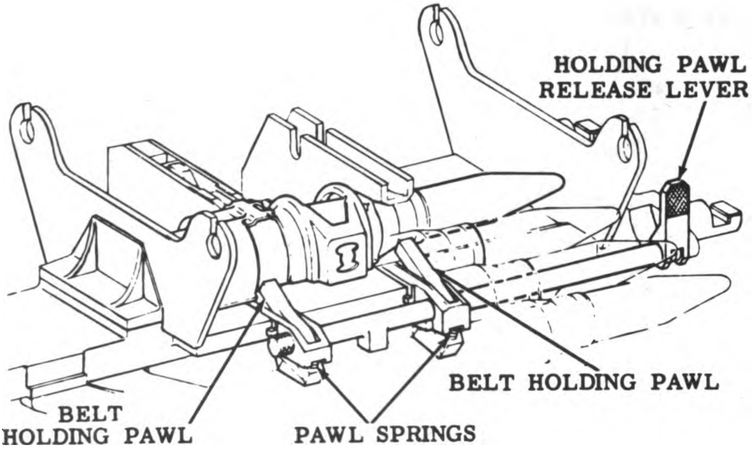


Figure 3–64.—Belt holding pawl action.

1. Springs push belt, holding the pawls UP to hold round in feed mechanism.

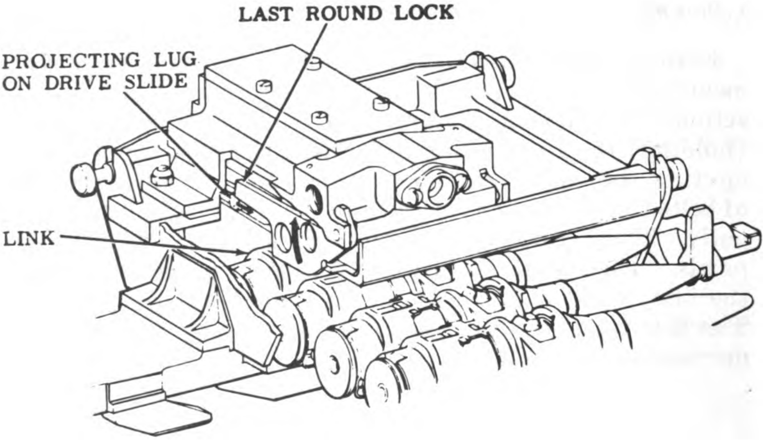


Figure 3–65.—Drive unlocking action.

1. Link pushes last round lock up.
2. Last round lock releases projecting lug on drive slide.
3. Drive assembly is then unlocked.

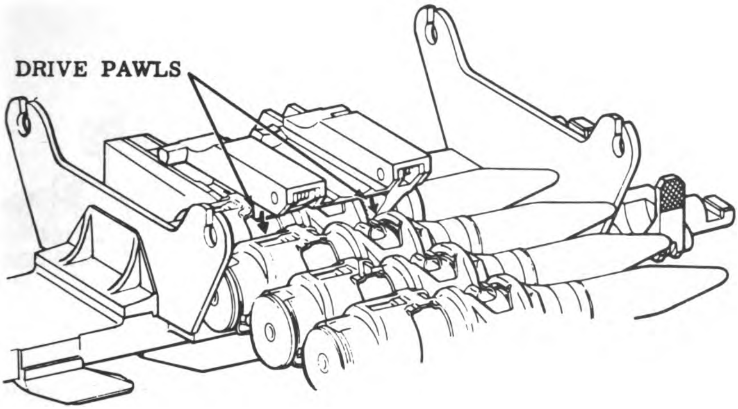


Figure 3–66.—Drive pawl action.

1. Drive pawl moves downward to engage link for drive stroke.

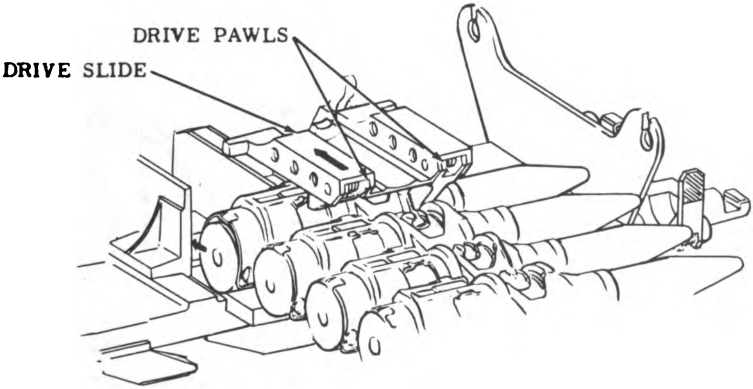


Figure 3–67.—Start of drive strokes.

1. Drive slide and connecting drive pawls push round inward.

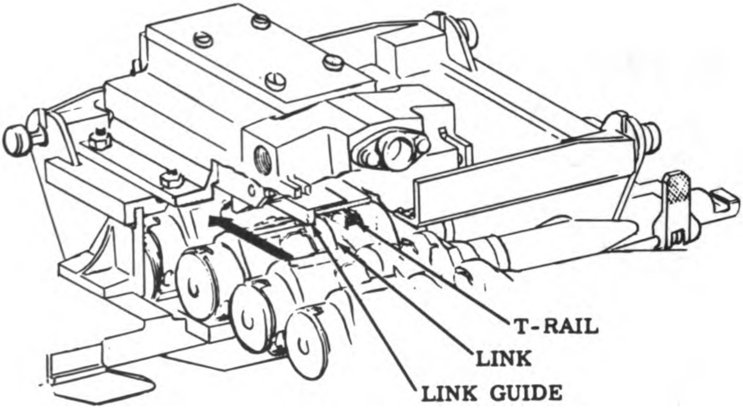


Figure 3–68.—Link guide and T-rail function in drive stroke.

1. As ammunition moves inward, T-rail engages loop of link.
2. Link guide prevents cocking of the links.

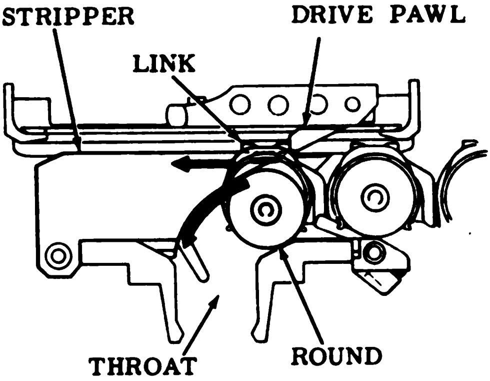


Figure 3–69.—Stripper function during drive stroke.

1. Drive pawl pushes link onto stripper.
2. Stripper cam surface guides round into throat.
3. Link and round stripping action begins.

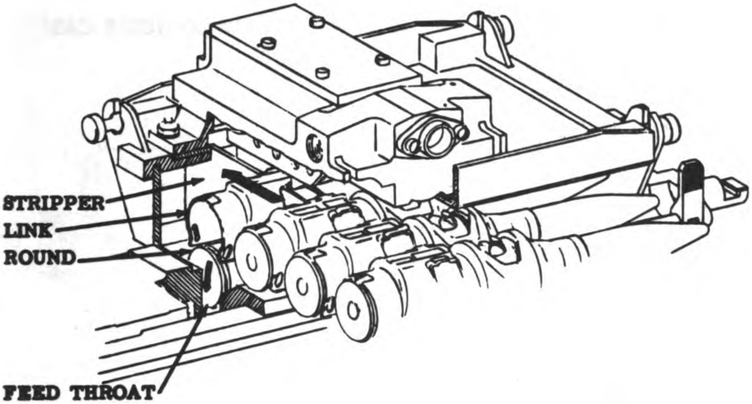


Figure 3–70.—Link stripped from round during drive stroke.

1. Link moves across top of stripper.
2. Round is guided into feed throat.

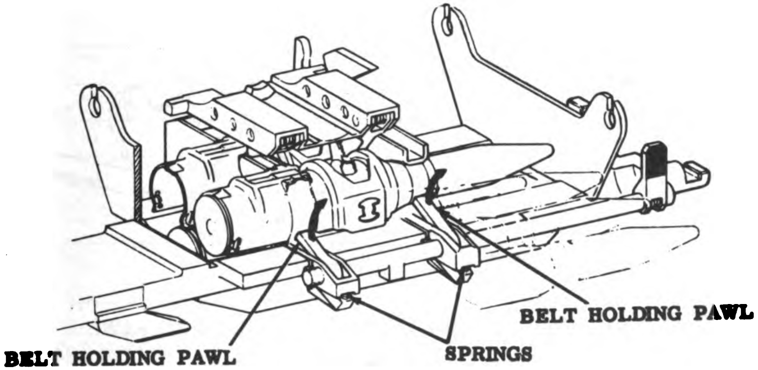


Figure 3–71.—End of drive stroke.

1. Spring pushes belt holding pawl UP to hold second round in feed mechanism.
2. Holddown pawl bears on top of stripped round.

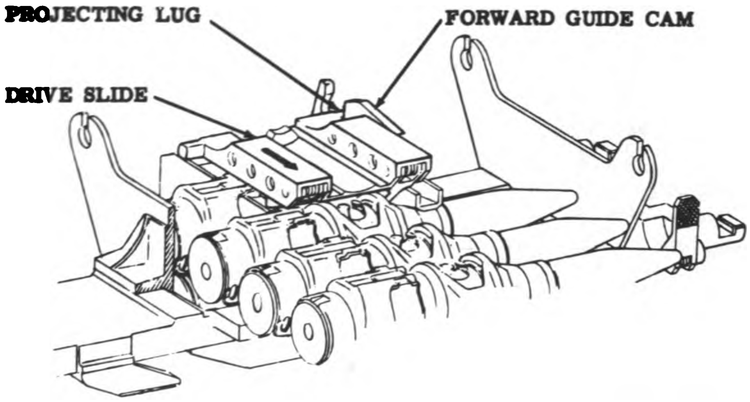


Figure 3–72.—Start of return stroke.

1. Drive slide moves at start of return stroke.
2. Projecting lugs on drive slide engages rear of forward cam guide.

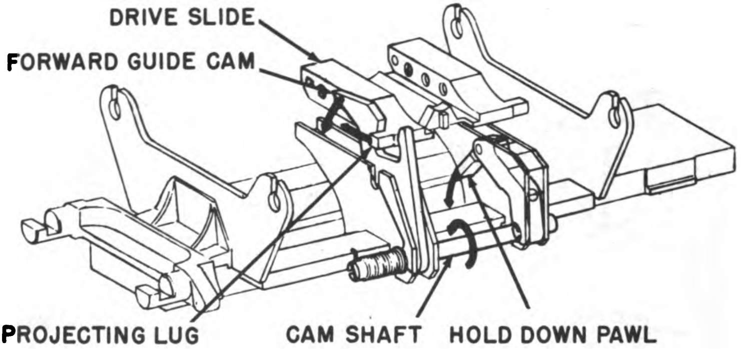


Figure 3–73.—Return stroke actions.

1. Drive slide projection lug engages and pivots the forward guide cam.
2. As cam pivots, camshaft rotates.
3. Turning camshaft pivots the holddown pawl downward.

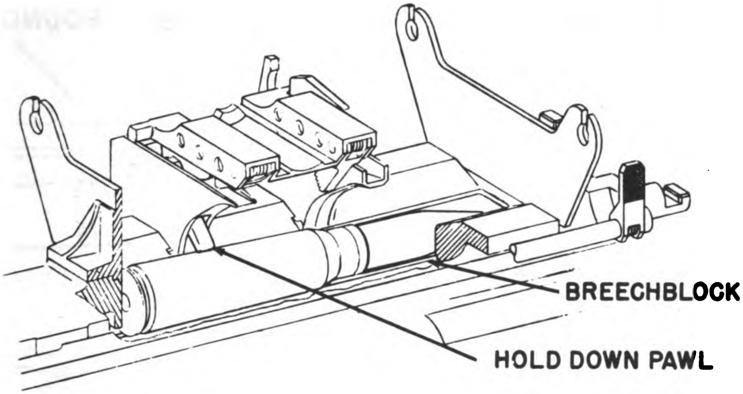


Figure 3–74.—Round on top of breechblock during return stroke.

1. Round rests on top of breechblock. (First stall position.)
2. Holddown pawl rests on top of round. Since the round and holddown pawl cannot move, return action stops.
3. Stall condition continues until breechblock is moved rearward by charging.

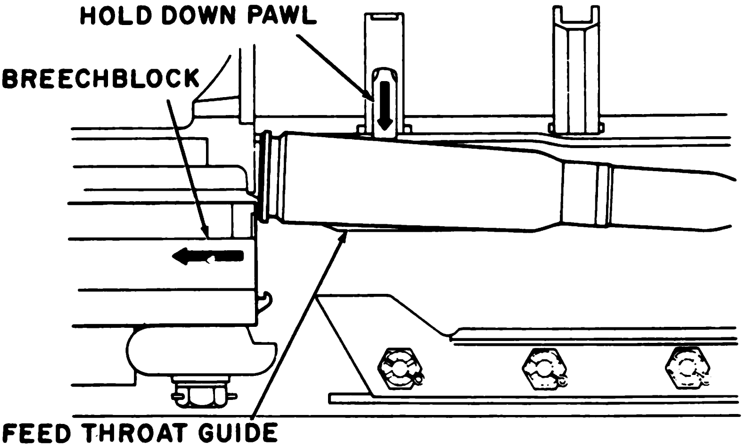


Figure 3–75.—Round in mouth of feed throat during return stroke.

1. When beechblock moves rearward, round is pushed down into feed throat guides by holddown pawl.

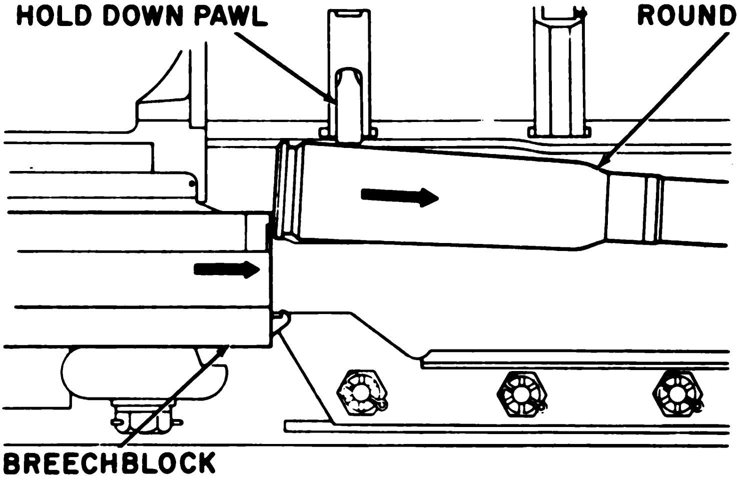


Figure 3–76.—Round ready for ramming during return stroke.

1. Breechblock moves forward and pushes round forward.
2. Feeder action is stalled until holddown pawl is released when round clears the pawl. (Second stall position.)

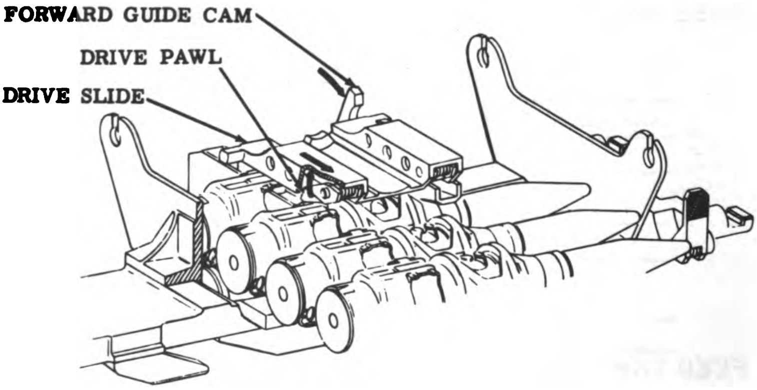


Figure 3–77.—Continuing return stroke.

1. After antifeed pawl is released, drive slide can continue return stroke.
2. Drive pawls pivot upward and pass over link.

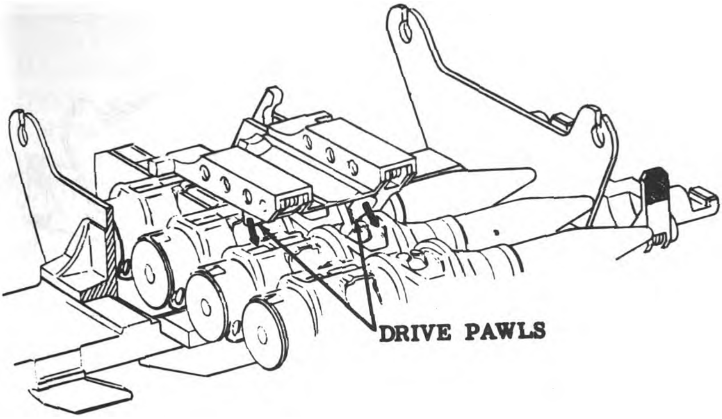


Figure 3–78.—End of return stroke.

1. Drive pawl pivots downward.
2. Cycle completed.

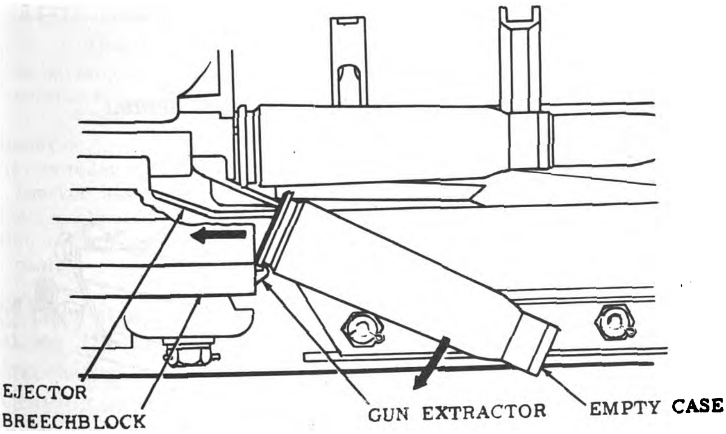


Figure 3–79.—Empty case ejection.

1. Blowback moves empty case and breechblock rearward.
2. Top of empty case butts against ejector.
3. Breechblock continues rearward movement.
4. Case pivots downward and is ejected from gun receivor.

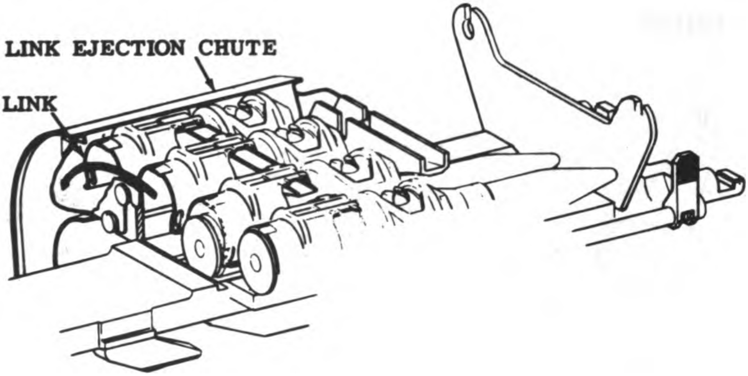


Figure 3–80.—Link ejection.

1. Empty link is pushed into link ejection chute by the drive pawl action.

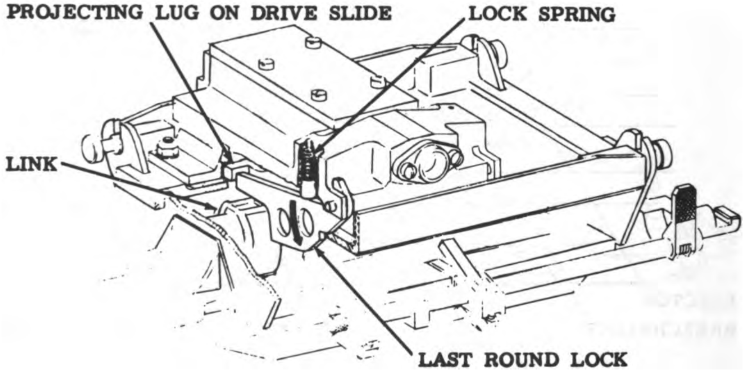


Figure 3–81.—Last round locking action.

1. When last link has cleared last round lock, the lock spring pushes lock downward.
2. Lug on drive slide engages end of last round lock and stops drive movement.

MAINTENANCE OF MK 12 MOD 0 GUN.—Inspection, careful servicing, and proper lubrication are absolutely essential for preservation and reliable performance of the Mk 12 gun. Aircraft guns require this particular care, since they are subjected to extreme and frequent temperature changes.

Guns that are in active use must be cleaned and lubricated daily, or after 600 rounds if additional rounds are to be fired the same day. Daily inspection (before and after flight) and maintenance schedules are as follows:

DAILY OR BEFORE OPERATING:

Item	*Procedure*
Gun barrel	Check for corrosion and fouling. Clean.
Receiver	Check for corrosion and dirt. Clean.
Breechblock assembly	Check electrical circuit.
Charger	Check operation. Check for leakage.
Buffer	Check for leakage.
Feed mechanism	Check operation. Check for leakage.

AFTER FIRING:

Item	*Procedure*
Gun barrel	Clean and lubricate.
Breechblock	Remove, disassemble, and check parts for breakage or damage. Clean and lubricate.
Receiver	Clean and lubricate.
Gas cylinder sleeve and bracket assemblies.	Check for fouling of vent plug and broken or cracked parts. Clean.
Feed mechanism	Clean and lubricate.
Gun mechanism in general.	Examine for broken, deformed, or worn parts.

After firing, use dry-cleaning solvent for cleaning all parts except the bore and breechblock. To clean the bore and breechblock, use the specified rifle bore cleaner. The dry-cleaning solvent may also be used for removing preservative from new parts. Since several of the components of the gun may not be subjected to vapor degreasing or immersed in solvents, such treatment is not recommended for any of the parts. The solvent specified for this cleaning has a fast degreasing action, is noncorrosive, and dries rapidly. Gloves should be worn when handling cleaned parts to prevent corrosion caused by perspiration. The dry-cleaning solvent will not remove powder fouling.

Thorough cleaning of the barrel is important. When the gun is fired, the gas pressure forces a deposit of primer salts into the pores of the bore and chamber. These salts are extremely corrosive, and if not removed promptly, they will cause pitting and other forms of corrosion. An emergency cleaner for the bore and chamber may be made by mixing one-half ounce of sodium carbonate in one gallon of boiling water. After using this cleaner, rinse the barrel and parts with fresh water and dry carefully.

A SET OF TOOLS is provided for disassembly, assembly, cleaning, and preserving the gun. For a complete list of these tools, refer to NAVORD List No. 23751. These tools should not be used for purposes other than those for which they were intended. Two barrel tools are provided for removal of the barrel: the LOCKING-PIN REMOVAL TOOL and the BARREL STRAP WRENCH. Tools are also supplied for gaging and cleaning the bore. A BOLT UNLOCKING TOOL is provided for unlocking and removing the bolt assembly from the receiver. A BOLT CONTACT EXTRACTOR TOOL is provided for removing the firing circuit contact. An ohmmeter and a megger are provided for checking the firing circuit.

TROUBLE ANALYSIS AND CORRECTIVE PROCEDURE for the Mk 12 gun are briefly listed for reference:

Misfire—Any stoppage of the gun will be considered a misfire when the receiver is not visible or when the bolt is in battery with a round in the chamber. When a misfire occurs, wait 30 seconds from the time of misfire and recharge the gun. Immediately immerse the round in water. If the gun is hot and the round cannot be removed, the bolt should be kept in the battery position until the hand can be placed on the barrel comfortably. No corrective action may be taken in the air except to recharge the gun. If it fails to fire after recharging, secure the gun. Under battle conditions this may not be practicable. A hangfire should not be cleared from a hot gun for 30 minutes, unless it can be cleared between 30 and 45 seconds after it occurs.

Failure to fire.—This trouble may be caused by a defective cartridge primer, an open firing circuit, or a shorted firing circuit. The round must be treated as a misfire. Check the circuit for continuity and for shorts. Examine the firing pin for breakage and replace if necessary. Examine the firing pin guide for breakage or upsetting of the metal around the slide key slot. Examine the firing pin spring for breakage.

Failure to feed round—This type of failure may be caused by one or more of the following troubles:

1. Broken components of the magazine or feed slide anchors.
2. A deformed or burred feed mouth.
3. Excessive friction in the feed mechanism.
4. A broken or jammed ammunition belt in the ammunition box or feed chute.
5. Broken links or a link jam in the link chute.
6. Insufficient recoil of the bolt assembly.
7. Breechblock out of position.
8. Improper alignment of the feed mechanism.
9. Broken or damaged feed mechanism parts.

Failure to extract—Extraction failure is evident by a case remaining in the chamber, or by the jamming of another round against the empty case in the chamber. This is caused by a broken extractor, extractor spring, pin, or by dirty ammunition or chamber. Normally, a failure to extract may be cleared by charging the gun, unless the extractor, extractor pin, or extractor spring is broken. Should the extractor rip through the empty case rim, remove the round with the RUPTURED CASE REMOVAL TOOL.

Failure to eject—Faulty ejection will generally result in a jammed gun. Examine the feeder for a broken ejector, ejector lock, ejector spring, or ejector lockscrew. Check the bolt for a broken extractor, extractor pin, or extractor spring.

Runaway gun—Continued firing after release of the firing switch is almost always the result of a defective firing switch.

Slow-firing gun—A free-firing gun which fires at a rate less than that for which designed should be checked for:

1. Buffer leakage or low air pressure.
2. Excessive lubrication or dirt in the breechblock and receiver slides.
3. Fouling of the gas bracket vent plug or barrel port.
4. Free operation of the entire gas mechanism.
5. Electric firing circuit opens and shorts.
6. Freedom of receiver in aircraft mounting.
7. Binding of the recoil mechanism.

GENERAL MAINTENANCE OF MK 7 MOD 0 FEED MECHANISM.—

The feed mechanism is kept ready for instant and proper operation by periodic inspection, lubrication, and preservation. Keep the mechanism free of excess oil, dirt, rust, and corrosion. Weekly, and before firing, clean all accessible ports with dry-cleaning solvent, and then wipe with a clean cloth dampened with an approved lubricating oil or grease.

Caution: Do not dip the feed mechanism in any cleaning fluid oil.

Sluggish or unsatisfactory operation may result from the use of improper lubricants or excessive lubrication.

Salty or moist atmospheric conditions tend to cause water to emulsify with oil. Combine this condition with extremely low temperatures, and the mechanism will probably become inoperative due to ice formation if improper or excessive lubrication is used. In dusty or sandy areas, lubrication should be kept to a minimum. The abrasive materials collected by the lubricant cause excessive wear.

NOTE: An air dehydrator should be placed in the compressed air line from the compressor to the feed mechanism. Moisture collecting in the drive subassembly from an undehydrated system will cause malfunctioning or failure at low temperatures.

Before LOADING AMMUNITION, make sure that the air pressure is shut off and that the air lines are relieved of pressure. If this precaution is not observed, the first round will automatically start the drive subassembly, possibly injuring personnel. Guide the belted ammunition through the feed chute. Push the first round over the belt holding pawls until these pawls return to their normal spring-held position.

If a manually operated air supply valve is installed, the mechanism may be operated to index the first round. Keep the hands away from the mechanism and open the air valve sufficiently to index the first round. This action strips the first round and places it on top of the breechblock. The drive subassembly stalls since the holdback (belt holding) pawl is forced against the round by mean of the camshaft and the drive subassembly. SHUT OFF AND RELIEVE THE AIR PRESSURE. Check the round on top of the breechblock by slightly raising the cover of the feed mechanism and observing the round in the mechanism forward of the link ejection chute.

To UNLOAD THE BELTED AMMUNITION, first shut off and relieve the air pressure. Push and turn the two cover latch pins on the link ejector side of the feeder to the unlatched position. Grasp the cover near the link ejection chute and pull upward. This action will strip the round in the feeder. Depress the belt holding pawl release lever and pull outward on the ammunition belt. If the mechanism has not been cycled, unload the ammunition by depressing the holding pawl release lever, and pulling out on the ammunition belt.

When the FEEDER IS UNLOADED AFTER FIRING THE GUN, one round remains in the mouth of the feed throat and one round remains in the barrel chamber. THEY MUST BE REMOVED. To remove the feed throat round, disengage the feed and link chutes and remove the feed mechanism from the gun receiver. Turn the mechanism upside down to unload this round. To remove the round in the barrel, see that the gun is pointed in a safe direction. Next, place the gun charging switch in the SAFE position. This action starts the charging cycle described elsewhere in this book. During the first half of the charging cycle, the round in the barrel will be extracted and ejected.

PREFLIGHT CHECK of the Mk 7 Mod 0 feed mechanism is listed in brief for reference:

1. Check both the feed chute adapter and the link ejection chute installations for proper connections.
2. Insure that the feed cover is securely locked to the feed throat. The latching pins have a shoulder that engages slots in the feed throat plates. Make sure that each latch pin is fully extended.
3. Check the security of the feed mechanism installation. Tie bar assemblies must be properly attached to the nonrecoiling part of the gun. The feed throat lugs must be properly engaged to the gun receiver body. Check the alignment of the rear of the feed mechanism and the index line on the gun receiver body.
4. Make sure that the first round is properly positioned against the belt holding pawls.
5. Check air hose connections to the drive subassembly. Leaks in a crossed thread can cause an operational failure.

A SAFETY DEVICE FOR USE WITH THE 20-MM MK 12 (AND OTHER MARKS AND MODS) GUNS.—Some naval activities have locally prepared a safety device for their 20-mm aircraft guns which absolutely prevents accidental firing of the guns while being loaded, unloaded, and otherwise checked on the ground. This device is easily constructed from scrap metal available to each activity, and is simple to use. Figure 3–82 is a sketch of this device with the approximate dimensions shown.

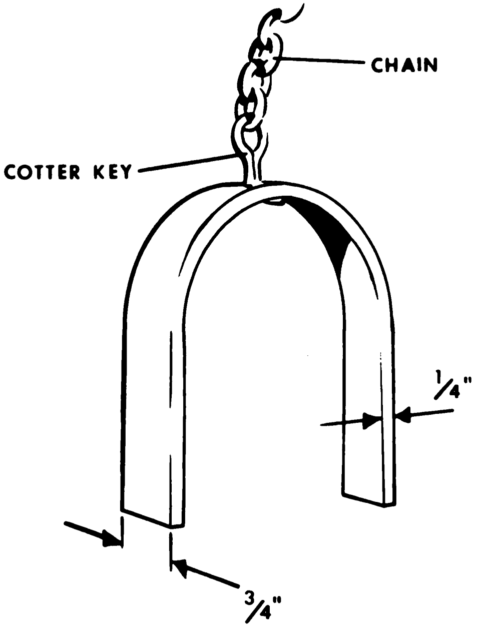


Figure 3–82.—Safety device for 20-mm guns.

This safety device may be chained together in pairs when used on guns mounted in pairs, or used singly on individual guns. It is most important to have the chains long enough to be visible to the pilot and ordnance personnel, and to have red bunting (or other appropriately colored material) attached to the chain, in order that the safety device will be invariably seen and withdrawn from the gun prior to replacement of the slide cowling and fastening of access doors over the guns.

The device is constructed from a soft iron strap or aluminum sheet, roughly ¼ inch in thickness and ¾ inch wide.

The piece measures roughly 7.5 inches before bending into a U-shape. The radius of the bend in the strap equals the diameter of the gun barrel at the breech end PLUS $^{3}/_{16}$ inch. This larger radius insures easy placement and retraction of the device. A cotter key is run through and spread in a hole drilled in the center of the bend on top of the device and serves to anchor the chain. To insert the device (breechblock must be in the aft position and held there by the last round lock or other restraining devices) move the PUSH RODS aft with the fingers and drop the safety device over the barrel between the ends of the push rods and the rear of the GAS CYLINDER SLEEVE. As long as the device remains in this position, the gun cannot be fired. To withdraw the device, simply lift it out by the chain.

GLOSSARY

BREECHBLOCK: The term breechblock indicates the assembly in the gun consisting of the bolt, slides, keys, firing pin assembly, etc. In operation of the feed mechanism and the gun, the round is fed down and actually rests on the top of the bolt.

CYCLE: One complete series of events which repeat themselves.

DRIVE STROKE: The drive stroke refers to the movement of the various components of the drive subassembly when it is feeding a round into the mechanism.

INDEX: The action of movement from one position to another. A step in a series of operations.

RETURN STROKES: The return stroke refers to the movement of various components of the drive subassembly when it is moving from the end of the drive stroke position to its initial position to begin another drive stroke.

STALL CONDITION (POSITION): This condition (or position) refers to the TWO instances when the motion of the drive subassembly has stopped. In the first instance, the round is positioned on the top of the breechblock. In the second, the round is in the mouth of the feed throat and is waiting for the bolt to ram the round into the chamber of the gun barrel.

STRIPPING: Stripping refers to the action of removing the links from the rounds.

QUIZ

1. The allowable free length of the M3 20-mm gun driving spring should measure from
   a. 23 to 26.25 inches
   b. 25 to 31 inches
   c. 27.5 to 31.25 inches
   d. 27.25 to 30 inches
2. Which one of the following M3 gun components is a nonrecoiling group?
   a. Magazine slide group
   b. Gas cylinder and sleeve group
   c. Rear buffer group
   d. Sear and sear block group
3. The gas port in the tube of the M3 gun is cleaned with a
   a. 22 gage wire
   b. sear spring
   c. #22 drill
   d. #45 or #46 drill
4. The scribe (engraved) lines on the M3 20-mm gun should be
   a. 1/18 inch apart
   b. 1/8 inch apart
   c. lined up flush
   d. one inch apart
5. At the instant of firing, the breechblock of the M3 20-mm is positively locked in battery by the
   a. breechblock lock
   b. breechblock slides
   c. locking key
   d. receiver slides
6. The cartridge control pawl of the AN–M2 feed mechanism is actuated by
   a. incoming rounds of ammunition
   b. cartridge holding dog
   c. outgoing rounds of ammunition
   d. cartridge holding cams
7. The torque stabilizer of the AN–M2 mechanism is located in the
   a. frame and mouth group
   b. starwheel housing group
   c. clutch drive group
   d. none of the above
8. The recoil housing of the M3 gun contains
   a. ring springs
   b. coil springs
   c. braided springs
   d. ring and coil springs

9. The 20-mm gun should be cleaned each day and after firing
   a. 300 rounds
   b. 400 rounds
   c. 600 rounds
   d. 900 rounds

10. The distance from the base of the cartridge case to the bottom of the double loop of the link on a round of 20-mm ammunition should be
    a. $2\frac{11}{16}$ inches
    b. $2\frac{9}{16}$ inches
    c. $2\frac{9}{32}$ inches
    d. $1\frac{7}{8}$ inches

11. When a misfire occurs during ground testing, you should
    a. check the electric trigger
    b. charge the gun immediately
    c. press the trigger rapidly
    d. wait at least 30 seconds before charging the gun

12. To insure against the breechblock slides rebounding, the breechblock has
    a. floating inertia blocks
    b. a positive locking action
    c. breechblock slide springs
    d. a breechblock lock

13. Which of the following is responsible for returning the 20-mm Gun M3 to the battery position?
    a. Recoil housing
    b. Blowback
    c. Inertia
    d. Recoil spring

14. The ejector of the 20-mm Gun M3 is part of what group?
    a. The breechblock
    b. The receiver
    c. The magazine slide
    d. The rear buffer

15. What is the purpose of the cartridge holding dog in the AN–M2 feed mechanism?
    a. To actuate the cartridge control pawl
    b. To retain the last round in the feed mechanism
    c. To guide the last round into the chamber
    d. To actuate the cartridge holding cams

16. The parts mainly responsible for maintaining firing speed of the 20-mm Gun M3 are the
    a. driving spring and rear buffer
    b. breechblock slide springs
    c. recoil spring and gas cylinder sleeve spring
    d. recoil spring and recoil housing

17. What size wrench is used to wind the AN–M2 feed mechanism?
   a. 7/16 inch
   b. 1/2 inch
   c. 3/4 inch
   d. 5/8 inch

18. The final shock of the M3 gun's recoil is cushioned by the
   a. recoil housing assembly
   b. recoil spring
   c. recoil spring seat
   d. rear buffer

19. The gas cylinder sleeve spring of the M3 gun returns which of the following to the battery position?
   a. Gun
   b. Gas cylinder sleeve
   c. Gas cylinder
   d. Push rods

20. How many ejector springs are in the Mk 7 Mod 0 feed mechanism?
   a. Four
   b. Two
   c. Three
   d. One

21. What stops the drive slide in the Mk 7 Mod 0 feed mechanism when the ammunition is exhausted?
   a. Drive piston
   b. Inertia blocks
   c. Belt holding pawl
   d. Last round lock

22. What synchronizing switch is used on the Mk 12 Mod 0 gun?
   a. AN–M4
   b. Mk 1 Mod 1
   c. Mk 1 Mod 0
   d. AN–M2

23. What drives the breechblock of the Mk 12 Mod 0 gun forward to fire the initial round?
   a. Charger
   b. Drive spring
   c. Pneumatic rear buffer
   d. Recoil spring

CHAPTER 4

ELECTRIC TURRETS

INTRODUCTION TO TURRETS

Rifles and pistols were the first weapons used in aerial warfare and were so ineffective that they were soon followed by mounted automatic weapons of one type or another. One of the major developments of early air combat, and the forerunner of the modern aircraft turret, was the SCARFF RING.

The Scarff ring was basically a rotating ring, secured around the edge of an open cockpit. The gun, in a swiveling mount, was secured to the ring, and the gunner stood or sat in the cockpit, manually swinging the gun and mount around to bear on the desired target. The Lewis machine gun was the weapon generally used until the Browning aircraft gun replaced it.

This manual operation was entirely satisfactory (though not necessarily ideal) until airspeeds climbed above 150 knots. As a case in point, modified versions of the Scarff ring were used in both the SBD dive bomber and the PBY patrol bomber, both of which were real workhorses for the greater part of World War II.

As aircraft speeds increased, it became more and more difficult for the gunner to swing the mount around against the slipstream while bracing himself to keep control of the gun during flight maneuvers. The powered turret was the answer.

Early turrets used hydraulic power to swing the turret in azimuth while the gunner elevated and depressed the guns manually. Later models had power operation in both azimuth and elevation, and by 1942 the electric turret had been developed. Modern turrets are either electric or use a combination electrohydraulic system.

The first real combat use of the aircraft turret, in the early days of World War II, is quite a dramatic story. In June 1940, the British and French armies in France had been decisively defeated in the "blitzkrieg" advance of the powerful German army and the collapse of France itself was at hand. However, the British had made an orderly retreat to the seacoast near Dunkerque, where an attempt was to be made to evacuate them, using every available vessel from fishing boat to destroyer. If the attempt failed, England would have virtually no land forces to defend herself against invasion. If the attempt succeeded, most of the British army would be saved, even though all heavy equipment would be lost.

The Germans, fully aware of this, made an all-out effort to crush the British forces, and kept them under artillery fire as well as almost constant air attack. On the second day of the battle, the Royal Air Force, fighting for control of the air over the beach, sent in a squadron of Boulton-Paul *Defiants*, two-seat fighter aircraft. Other *Defiants* had already fought the Luftwaffe, but these had ONE MAJOR DIFFERENCE—each plane was equipped with a hydraulic-operated turret mounting two caliber .303 machine guns.

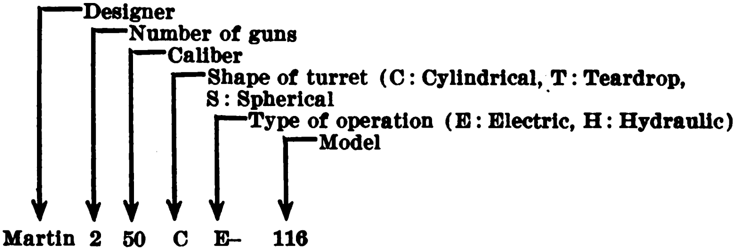
The results were spectacular. Gunners were able to track targets regardless of their own plane's speed or altitude, and the surprised Germans lost 37 aircraft. Not a single turret-equipped *Defiant* was lost. It was plain the aircraft turret not only had arrived but was here to stay.

The evacuation was a success, as history shows, and the battered British forces were returned to England where they were re-equipped and reorganized. The German Air Force and Army had suffered their first real setback and England was temporarily relieved of the threat of invasion. Later attempts by the Germans to concentrate landing craft met with defeat and no actual invasion was ever launched.

Soon after Dunkerque, American turrets were in production, some early models mounting one caliber .50 BAMG and later ones mounting two. All of these turrets were inhabited turrets, with the gunner sitting inside the turret structure. In some cases, more recent models have the gunner sitting outside, but adjacent to, the turret assembly, such as the Aero 11 series tail turret. This type of turret is considered to be locally controlled to distinguish it from the true remote-controlled type (used mainly by the Air Force) in which the gunner sits in a stationary sighting station some distance away, possibly controlling several turrets at once. The latest type is completely automatic, all target tracking, firing, and other functions being controlled by radar and other electronic devices. Turrets of this type are not discussed in this text.

Navy aircraft turrets are under the cognizance of the Bureau of Aeronautics, and are designated by the term Aero, followed by a number indicating the model, and usually by a letter following the number, indicating a modification. For example, the Aircraft Gun Turret, Aero 9 series, is an electrically operated bow turret. The second modification of the series is theAero 9B turret.

An earlier system of designation showed the name of the designer, number of guns, caliber of guns, shape of turret, type of operation, and model number. Using the Martin 250 CE–116 electric upper deck turret as an example, the designation breaks down as follows:


Designer
Number of guns
Caliber
Shape of turret (C: Cylindrical, T: Teardrop, S: Spherical
Type of operation (E: Electric, H: Hydraulic)
Model
Martin 2 50 C E– 116

A number of turrets employing this older system of designation are still in use. The later models of the Martin 250 CE series turrets are used in most P2V aircraft; however, Aero turrets mounting two 20-mm guns will replace it in new aircraft.

Turrets may be mounted in several locations in the aircraft, depending on the type and purpose of the plane. Most modern patrol planes have bow and tail turrets, both mounting 20-mm's, and a turret mounted topside in the fuselage, which is called an "upper deck" turret. Some models of patrol planes have fixed guns forward instead of a turret, while others have only an upper deck turret. At the other extreme was the P4Y–2 *Privateer* which was equipped with 6 turrets: a bow turret, 2 upper deck turrets, 2 waist turrets in the sides of the fuselage, and a tail turret, each mounting 2 caliber .50 machine guns. Needless to say, the squadron ordnancemen were busy men.

This chapter deals with the two electric turrets in current use, while the following chapter describes the electro-hydraulic turret. However, to understand the material in either chapter, you must first understand the fundamentals of electricity, as presented in *Electricity*, NavPers 10622–B. It is assumed you have already studied this training course; if necessary, review it before proceeding with ELECTRIC TURRETS.

THE MARTIN 250 CE SERIES

This turret is a self-contained, electrically-operated, upper deck type, most commonly seen in P2V aircraft. It mounts

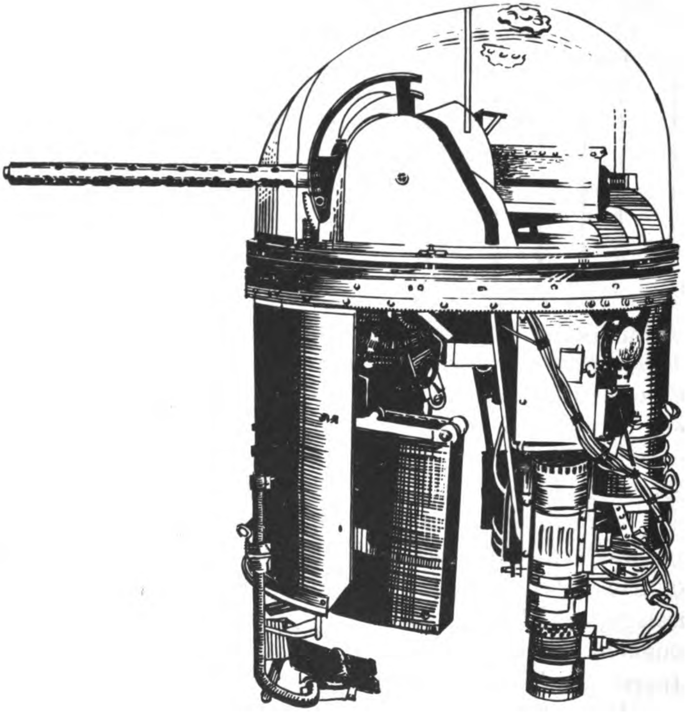


Figure 4–1.—Complete turret.

two .50 caliber aircraft machine guns which protrude from a plastic enclosure. The turret requires electrical connections from the aircraft's electrical power supply, as well as connection to the aircraft's interphone system. Each Martin upper deck turret has its own oxygen system.

The later models of the Martin 250 CE series are STABILIZED turrets. This feature automatically corrects for any aim-disturbing movement of the airplane, so that the guns remain pointed at the target regardless of roll, pitch, or yaw. The stabilization feature supplements the basic electric drive. This chapter deals only with the later turrets (250 CE 324 and later), all of which are stabilized.

The turret requires a maximum current of 170 amperes, except when a heated suit requiring an additional 25 amperes is in use. Power is transmitted into the turret by means of a collector ring and brushes. The turret drive is designed to furnish smooth operation at all speeds between ½ degree per second and 72 degrees per second in azimuth, and ½ degree to 48 degrees per second in elevation.

In this chapter all locations such as right-hand and left-hand refer to the gunner's right and left.

Turret Structure and Mechanism

TURNTABLE.—The whole turret is built upon the turntable, an aluminum alloy casting weighing about 75 pounds which is shown in figure 4–2. This casting is machined to provide for the mounting of the electric elevation and azimuth drive units, elevation drive torque tube, gun cradles, sight mounting yoke, gunner's seat, armor plate, plastic enclosure, ammunition booster unit, control unit, supporting rollers, and the fire interrupter. Two hoppers, which are part of the casting, direct empty cases and links into canvas bags.

OUTER RING GEAR.—The outer ring serves as a track inside which the turret rotates. In addition, it has a rack (gear teeth) machined around the bottom edge of the circumference (fig. 4–2). This circular rack mates with the pinion gear of the azimuth drive unit. Since the ring gear is stationary, with respect to the airplane, and the azimuth drive unit is mounted on the turntable, rotation of the pinion gear causes the turret to rotate inside the outer ring. The power collector ring, carrying a dangerously high amperage, is attached to (but insulated from) the outer ring.

ROLLERS.—The turntable is mounted in the outer ring by AZIMUTH, LOAD, and HOLDDOWN rollers, some of which can be seen in figure 4–2. There are 12 azimuth rollers which keep the turret from moving in a horizontal plane and when properly adjusted, make the turntable concentric within the outer ring. There are 10 load rollers which keep the turret from moving downward and thus take the normal gravity loads. Four adjustable holddown rollers take up loads caused by negative g's and also remove any mechanical play in a vertical direction.

ELEVATION MECHANISM.—As shown in figure 4–3, the elevation drive pinion engages with a gear mounted on the torque tube at the left of the turret center line. At each

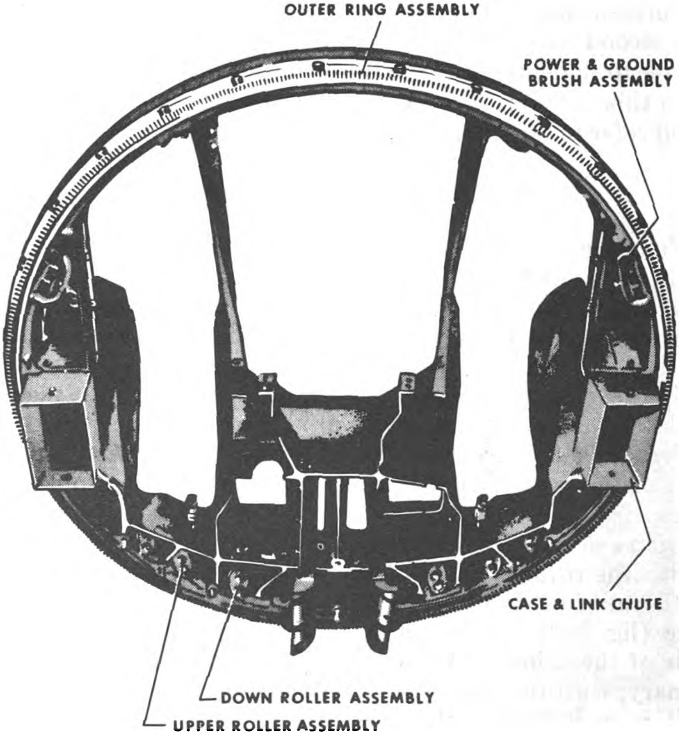


Figure 4–2.—Turntable and outer ring assembly.

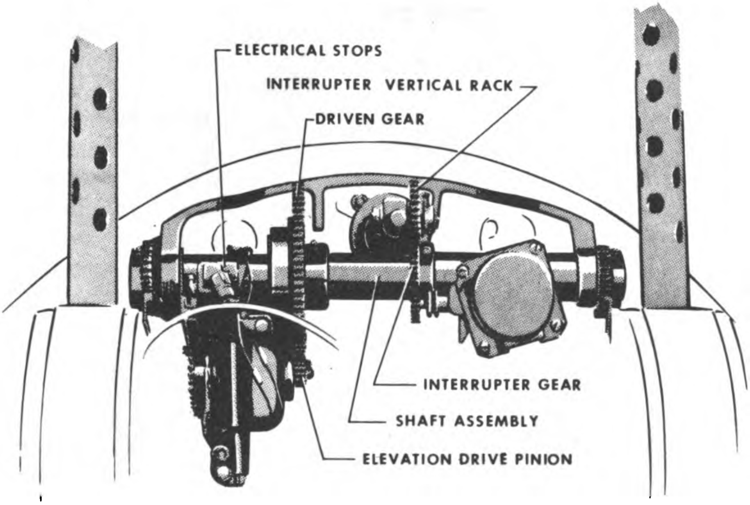


Figure 4–3.—Elevation mechanism—top view.

end of the torque tube is a driving gear which mates with a gear segment on the gun cradle (fig. 4–4). Thus, rotation of the elevation drive pinion causes the torque tube to rotate, which in turn causes the gun cradles to elevate or depress.

Gun cradles.—The gun cradles (fig. 4–4) are aluminum alloy castings. They are machined to provide for the installation of the gear segments, gun adapters, the adjustable rear gun trunnions, the metal curtain assemblies which close the slots in the plastic enclosure dome, the ejected case chutes, and the guards for the cartridge case and link hoppers. The gun cradles are installed as a complete assembly by two pivot pins which turn in bushings pressed in the turntable casting.

Ammunition boosters.—An ammunition booster unit is built into the turret as a feed assistor for each gun. Each unit consists of a hinged feedway, an electric motor, and a switch. As the feedway is tilted, due to the tension on the ammunition belt when the gun is fired or elevated, the switch closes thus starting the motor. The sprockets on the output shaft of the motor lift the ammunition belt and deliver it to the guns. The ammunition booster assembly is held

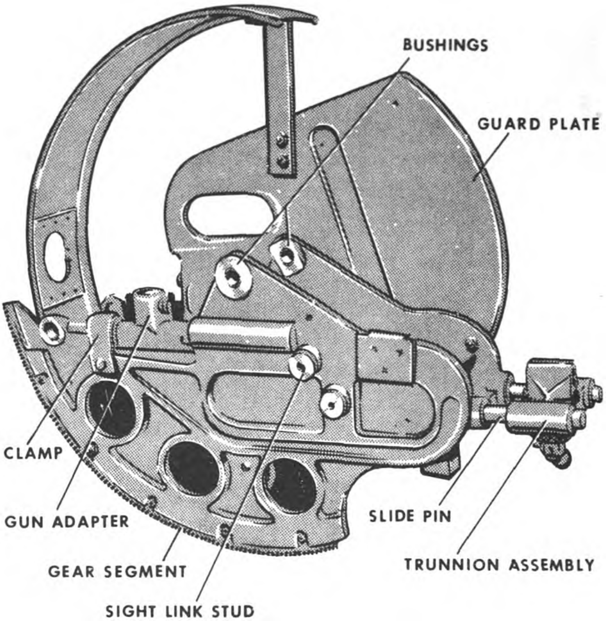


Figure 4–4.—Gun cradle.

by two studs attached to the lower armor support casting.

Seats.—The gunner's seat is secured to the turntable. The seat bottom is hinged at the back and is held in place by two catches, fastened to the bottom, which engage with holes in the sides. These catches may be released and the bottom dropped by pushing downward on a cable running between the catches along the forward edge of the seat bottom.

The main junction box is mounted on the underside of the seat bottom. A panel is attached to each side of the seat. These panels support the various units of the Mk 18 sight, as well as the interphone station box, oxygen outlet, heated suit receptacle, and the extension light.

Two cushions of different thickness are supplied with the turret. Either one or both may be used, depending on the gunner's height.

Armor plate.—Two pieces of armor plate, upper and lower, are arranged to protect the midsection of the gunner, the ammunition, and the turret mechanism from fire within an included angle of approximately 30 degrees in the direction in which the guns are pointed. On the inside surface of the lower armor plate, a track runs from one side to the other to provide for the installation of the 4 ammunition boxes. The footrest is also secured to the lower armor plate.

AMMUNITION BOXES.—There are 4 interchangeable ammunition boxes made of zinc-coated sheet steel, each with a capacity of 200 rounds of .50 caliber ammunition. When loaded, the boxes are no longer interchangeable from side to side.

MANUAL DRIVE.—A manual drive, controlled by two cranks, is provided for emergency operation of the turret in the event the electrical drive becomes inoperative. The assembly is bolted to the turntable just forward of and below the control unit.

The left crank operates the guns in elevation; the right crank operates the turret in azimuth and incorporates an emergency electrical trigger switch for firing the guns. With the selector switch on BOTH, the trigger switch will fire both guns; with the selector switch on IND, this trigger switch will fire only one gun. Each crank is connected to its respective drive by means of roller chains and sprockets and

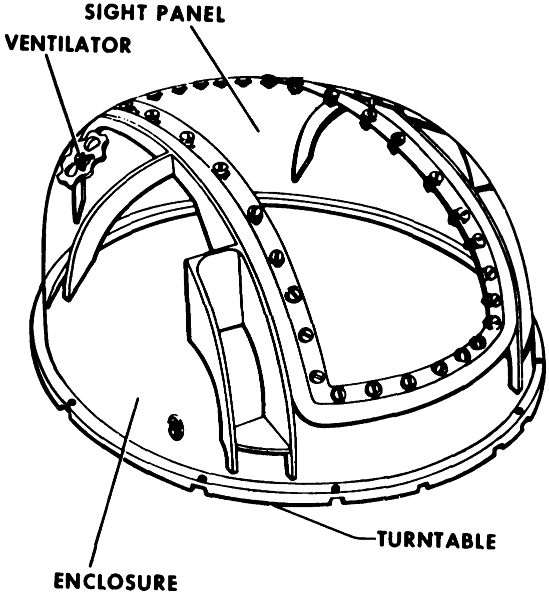


Figure 4–5.—Enclosure.

is disengaged from the drive system while in the stowed position.

Plastic enclosure.—The turret enclosure, or "dome," is made from a plastic transparent sheet formed while hot to give the proper shape (fig. 4–5). After cooling, gun slots and ventilator openings are cut and the reinforcing rib is cemented in place. The dome rotates with the turret structure and is secured to the turret by means of an external rib around the base, in which are 10 holes for mounting. The slots through which the gun barrels project are closed by the metal curtain assemblies on the gun cradles.

Turret Electric Drive

The turret electric drive consists of the main junction box, motor-generator, controller and control junction box, azimuth power drive and gear box, elevation power drive and gear box, and the structural interrupter.

Main junction box.—The main junction box houses the necessary electrical components that control and protect the various circuits in the system. It is a shallow metal box attached to the underside of the gunner's seat. The interior of the box is accessible for inspection or servicing by simply removing six screws and lifting off the cover.

Motor-generator.—The motor-generator unit provides 27.5-volt direct current to the drive motors. It is hung vertically from a bracket and held by a strap to the left side of the seat. The unit consists of a motor (prime mover), driven from the main power supply of the airplane, the elevation control generator at the top, and the azimuth control generator at the bottom. The three armatures are mounted on a common shaft and the units have a common housing. The motor and each control generator have a set of four brushes, mounted in easily accessible brush holders.

Controller and control junction box.—This assembly consists of a controller unit that is suspended from the control junction box and is free to swing, within limits, about the vertical axis. The junction box is bolted to the turret frame, so that the entire assembly is positioned directly in front of the gunner. (See fig. 4–6.) The controller contains hand control grips, an azimuth receiver, and an elevation receiver. The controller transfers the gunner's com-

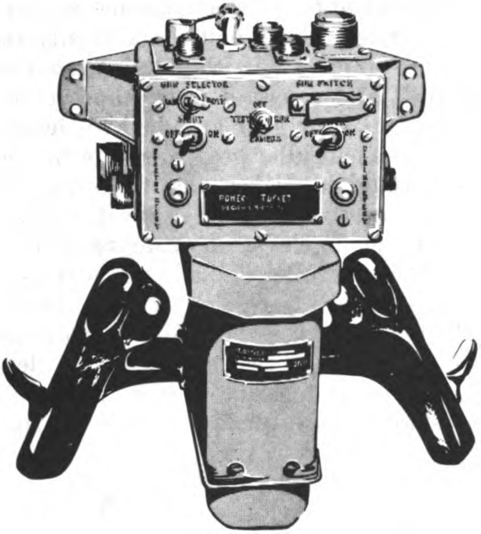


Figure 4–6.—Controller and controller junction box.

mands into electrical signals that in turn operate the turret and guns in the desired movements. This is accomplished through the hand grips which rotate about a vertical axis to control the rotation of the turret in azimuth, and about a horizontal axis to control the motion of the guns in elevation. Rotation of the hand grips is limited to about 22 degrees from the center position in both azimuth and elevation.

The hand grips are pistol type units. They are mounted on a cross shaft that extends horizontally through the controller. On the outboard side of each grip is an action switch which must be depressed before either the turret or guns can be operated. A trigger-type switch on the back of each grip fires the guns. Either one of the trigger switches will fire both guns simultaneously when the selector switch on the control box is in BOTH position. When the selector switch is in IND position, either of the guns may be individually fired. A microphone switch is located at the front of each grip in the thumb position.

The control grips shaft passes between the azimuth and elevation receiver units. Wiring from the switches passes through the grips and shaft, coming out through a hole in the shaft.

A bevel gear, pinned to the shaft, meshes with a bevel gear attached to a vertical shaft held in a steady-rest, located above the receiver units. Vertical displacement of the grips rotates this shaft and causes a gear segment on its top to mesh with a central spur gear attached to the elevation receiver. This acts as an idler gear to rotate the receiver side shaft which, through a driver and follower arrangement, turns the contact arm to make the electrical contact that starts gun movement either in elevation or depression.

Rotation of the controller about a vertical axis turns the controller about the steady-rest and causes the spur gear at the top of the azimuth receiver unit to turn against a gear segment fixed to the steady-rest. As with the elevation unit, the spur gear passes the torque to a segmental gear on the receiver side shaft. This turns the contact arm in the di-

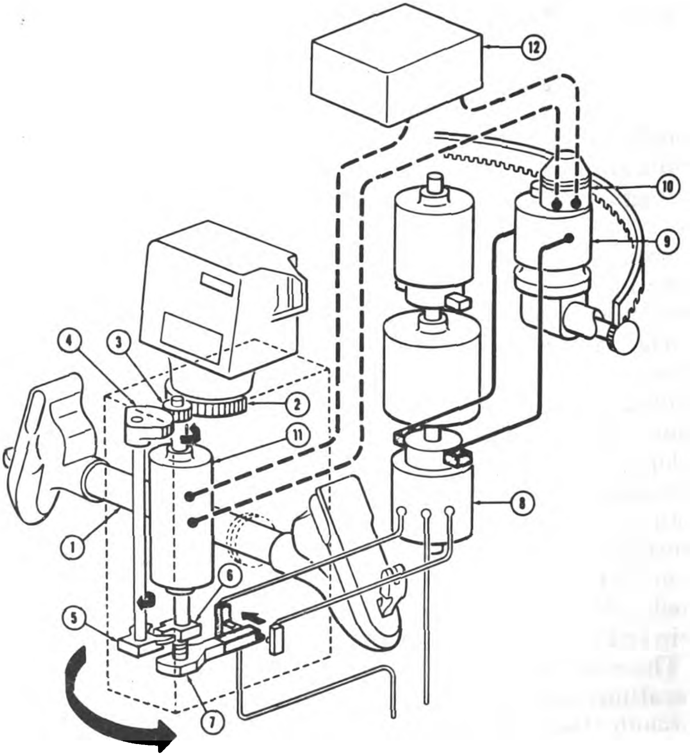


Figure 4–7.—Azimuth control diagram.

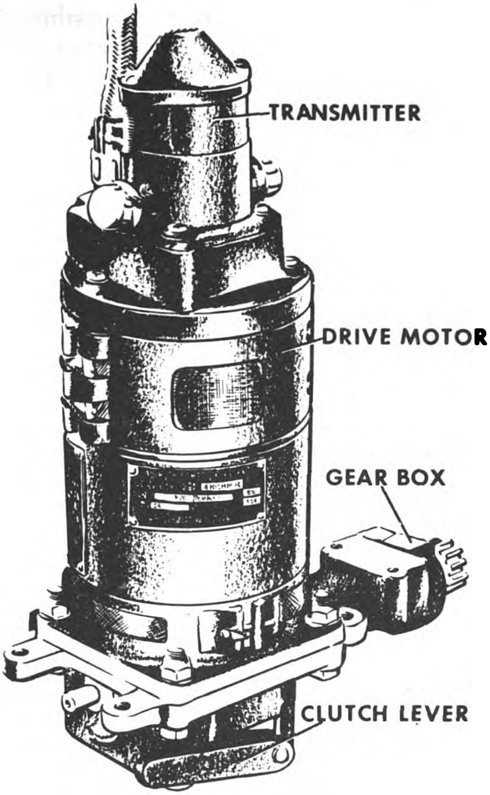


Figure 4–8.—Azimuth power drive and gear box.

rection signalled by the grips, and makes the electrical contact which causes the turret to rotate either clockwise or counterclockwise.

Azimuth power drive and gear box.—The azimuth power drive and gear box unit (fig. 4–8) consists of a drive motor, a transmitter, gear box, and clutch. This unit is mounted vertically in the right-hand side of the turret with the drive pinion meshed with turret ring gear. The electrical power to the drive motor is converted into mechanical power to rotate the turret in azimuth through the gear box and pinion and ring gear arrangement. The clutch device allows the worm gear in the gear box to be engaged when the turret is in power operation, or to be disengaged when manual operation of the turret is desired.

The azimuth drive motor is a reversible, d-c unit. It draws 2.5 amperes at 27 volts and is rated at 1 horsepower at 5,800 r. p. m. Four brushes are seated in a brush holder ring and each is accessible by removing a brush cap in the commutator cover.

The transmitter is a permanent magnet generator mounted to the commutator end of the drive motor by an adapter and is geared to the motor armature shaft. It is a 47.5-volt d-c generator, rated at 6,000 r. p. m. with a 0.6-ampere load. Energy produced by the transmitter is used to operate the azimuth torque motor in the controller.

The azimuth gear box is attached to the armature end of the drive motor and serves to link the drive motor with the turret ring gear. The worm on the drive motor meshes with the worm wheel on the gear box to give a gear reduction ratio of 10⅔ to 1.

ELEVATION POWER DRIVE AND GEAR BOX.—The elevation power drive and gear box is similar to that which drives the turret in azimuth and consists of a drive motor, transmitter,

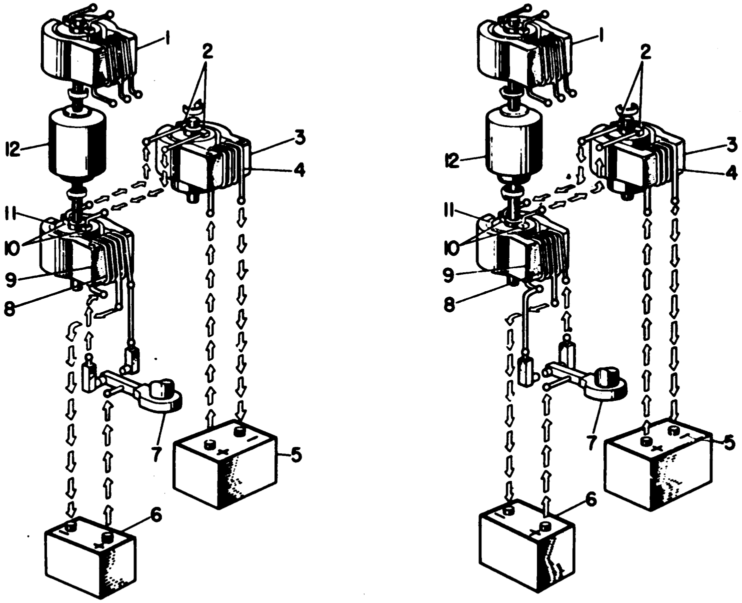


Figure 4–9.—Generator field reversal diagram. Model E1021 Drive.

gear box, and clutch. It is mounted in the left-hand side of the turret.

STRUCTURAL INTERRUPTER.—The structural interrupter is a limit switch connected electrically in the elevation drive circuit and mechanically to the azimuth and elevation drive gears. The purpose of this unit is to stop the guns at maximum elevation and to prevent the barrel jackets from striking the fuselage when moving the guns in depression.

PROFILE INTERRUPTER.—In addition to the structural interrupter, each turret is equipped with a profile interrupter. This unit interrupts gunfire when the guns are lined up with some part of the airplane. Thus, the gunner is free to concentrate on the target without fear of damaging his own aircraft.

The profile interrupter consists of a movable cam, two cam followers, and two microswitches. As the turret revolves, the cam is turned at the same rate. On the cam is engraved an exact duplication of the portions of the airplane which can come in line with the guns. These engravings actuate the cam followers which in turn actuate the microswitches. One microswitch is wired in series with each gun firing solenoid. Thus, when the switch is actuated, the circuit is broken and gunfire ceases until the turret is further revolved so the outline of the airplane is no longer in line with the guns.

Operation of Electric Drive

The first step in operating the turret is to close the power switch on the control junction box. Closing this switch energizes the master relay. Energizing the master relay completes the circuit to the action switches on the handgrips of the controller. Depressing either action switch and moving the control grips about the vertical axis then moves the turret in azimuth; moving the control grips about the horizontal axis moves the guns in elevation. Direction of turret or gun movement corresponds to direction of handgrip movement. Rate of turret or gun movement corresponds to the extent of handgrip movement. Since both azimuth and elevation circuits are identical, only the azimuth circuit is described. (Refer to fig. 4–9.)

NOTE: The following principles of operation apply to model E1021 Drive only.

When either action switch is depressed, an action relay closes, applying voltage to the movable contactor (7) and to the center tap of a resistor. This resistor is connected across the fields of the generator (9). Movement of the control grips applies a torque to the controller receiver through a spring, moving the movable contactor (7) against one of the stationary (fixed) contacts. This shorts one-half of the resistor and energizes one field of the generator, causing a voltage to be generated in the armature circuit. The polarity of this voltage is characteristic of the active fixed contact, causing drive motor rotation in the direction called for by displacement of the hand control grips. If the movable contactor had been driven to the other fixed contact, the other generator field would have been energized, generating a voltage of opposite polarity, causing rotation of the drive motor in the opposite direction.

Velocity control.—Figure 4–10 illustrates the electrical and mechanical connections to the turret drive. When the main switch (8) is closed, the motor-generator (6 and 7) begins to run and power is delivered to the action switches in the controller. Closing the action switches and moving the control grips (10) deflects the control spring (11), closing the contacts (12) to one generator field. This produces a current in the armature circuit, causing rotation of the tur-

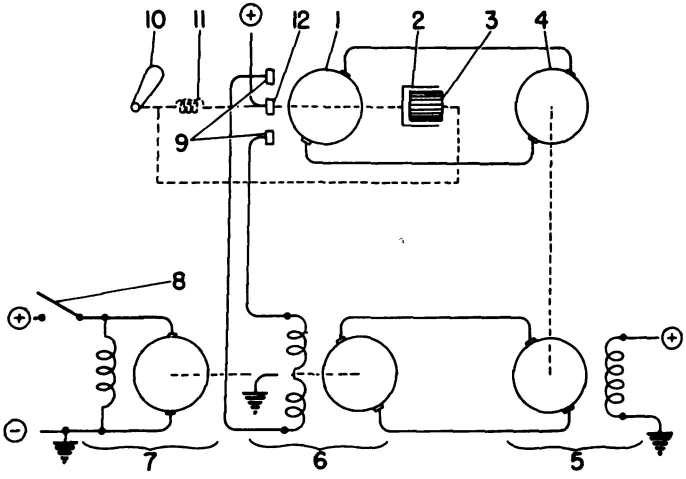


Figure 4–10.—Velocity control system, schematic diagram. Model E1021 Drive.

ret motor (5). Through the mechanical connection between the turret motor (5) and the transmitter (4), a voltage proportional to the speed of the turret motor is developed in the transmitter-receiver circuit, and appears as torque at the receiver shaft in a direction opposite control spring torque. Since the movable contact is attached to the receiver shaft as well as to the control spring, a sensitive, balanced system results.

In operation, the signal of the controller displacement starts the turret motor in a certain direction. When the speed reaches a value above the input signal, overbalancing the spring torque, the counter torque takes over, opening the generator field and reducing the speed of the turret motor. The balance is then in the direction of the input signal from the control grips. The contacts again close and the turret motor speed increases. The cyclic regulating action occurs in a series of rapid pulsations, producing an average constant velocity at the turret motor.

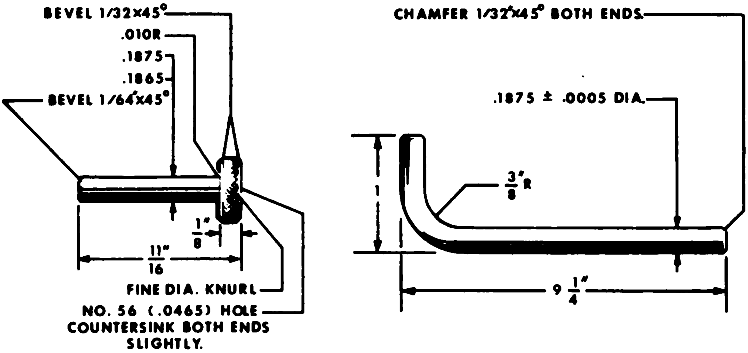
Stabilization System

In addition to the electric drive, later models of the Martin 250 turret are equipped with a stabilization system. The stabilization system supplements the basic electric drive used to position the guns in elevation and the turret in azimuth. The stabilization feature automatically feeds corrections into the basic drive system, compensating for unwanted aircraft movements, such as pitch, roll, and yaw. This is accomplished by the proper use of gyroscopes with an indication device and a servo amplifier to amplify the indicated force, and automatically modify the signals called for by the displacement of the control grips.

Maintenance

The most effective maintenance is PREVENTIVE maintenance—doing a little work now to correct a minor trouble instead of considerable work on a major trouble later. A thorough visual examination of equipment during the periodic checks often uncovers conditions that might cause trouble later. For example, fray marks on a flexible cable would indicate that the cable should be moved to a position where it will not rub against the surface that caused the fraying.

Any sudden or unusual change in the appearance of any component should be investigated, its cause remedied, and the component replaced if defective. Electron tubes should be pressed firmly into their sockets and connectors examined for signs of a loose fit. Also examine for loose fit each component that is secured with screws or bolts. Voltages used in this equipment require clean leads and connections. Clean equipment, free of dirt, will give much less trouble than dirty equipment. All of the component units of the drive system, except the gyros, may be cleaned with a stream of filtered compressed air of less than 30 pounds gage pressure. Grease spots should be removed with a nonexplosive solvent. A vacuum cleaner may be used inside the turret to remove loose dirt.



SETTING-PIN

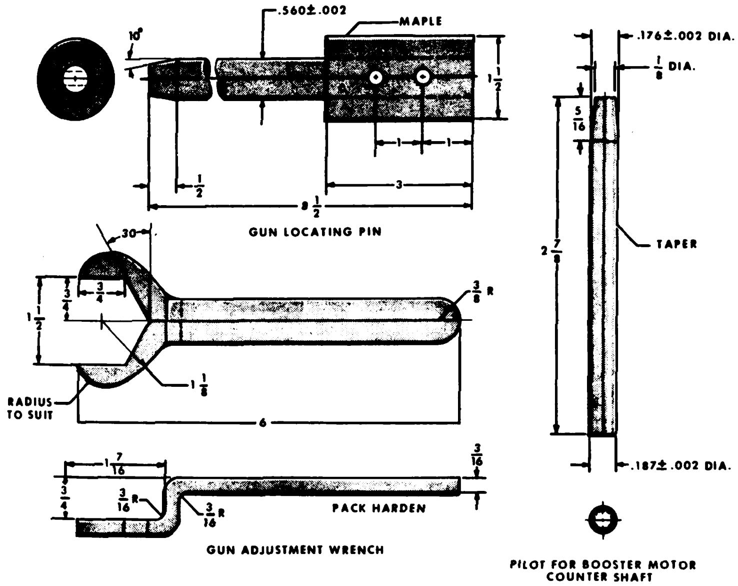
LOCKING-PIN

Figure 4–11.—Service tools required.

Stabilization Test Unit Aero 1A is used (1) for alignment of the electric drive after installation of the drive; (2) for checking alignment and response of the stabilization system during periodic inspections; and (3) for alignment checks after replacement or adjustment of units of the stabilization system. Detailed instructions for using the test unit are contained in the handbook of operation and service instructions for the turret concerned.

Special tools required in servicing the turret are shown in figures 4–11 and 4–12.

Operational check.—***Caution:*** Make sure the guns are not loaded.



GUN LOCATING PIN

GUN ADJUSTMENT WRENCH

PILOT FOR BOOSTER MOTOR COUNTER SHAFT

Figure 4–12.—Special turret tools.

Check the operation of the control grips with power off to see that there is no binding over the entire range of travel and that the control grips are tight on their mounting shaft.

Close the power switch and then each action switch in turn to see that the motor-generator starts.

NOTE: Some motor-generators start on closing the power switch.

Check the operation of the turret in azimuth and elevation for smooth operation, and response to control grip deflection.

Turn the turret to a position where the guns are free to move through their entire range in elevation. Run the guns all the way up and down to see that the structural interrupter operates.

Close main firing switch on controller panel, depress the firing switches, and rotate the turret while visually inspecting the operation of the profile interrupter.

Set selector switch to IND. Close right trigger switch and listen for right solenoid to operate. Check left gun solenoid in the same manner. Set selector switch to BOTH and again test trigger switches. Either switch should operate both solenoids. Turn switch to OFF and see that solenoids do not operate when triggers are pressed.

Depress the guns against the down stops and hold them there with a slight pressure. Rotate the turret in azimuth at low speed and check that the guns do not strike the fuselage.

Test the ammunition booster motors by tilting the boosters toward the guns. Make sure the motors cut on and off sharply without lag.

General maintenance.—After each flight, clean plexiglas dome with soap and water and a soft cloth.

Clean guns and install gun covers after each flight.

Clean gun cradles if necessary. Do not lubricate them.

Replace the slide castings on the rear mounting trunnions if the bushings are excessively worn. Boresight guns after this operation.

Keep the manual drive roller chains free of play.

Clean the junction box contacts when they are pitted or corroded or when there are signs of sticking.

If the drive motor commutators are dirty or corroded, sand them lightly with No. 0000 sandpaper. Do not use emery cloth. Blow out all dust after sanding. Do not lubricate the commutators in any manner.

Replace any nuts or bolts that have damaged threads. Replace broken safety wire.

Before leaving the turret, always bring the guns to 180 degrees azimuth (pointing directly aft) and zero degrees elevation and engage the clutches. This prevents the turret from swinging as the airplane banks.

Boresighting.—The guns and sight must be boresighted after any one of the following operations: installation of the gunsight, temporary removal or replacement of the complete sighting head, or installation or replacement of a gun or guns.

Boresighting procedure: Level the airplane. Place the turret in a position other than zero or 180 degrees azimuth. Place the gun cradle at zero degrees elevation and insert the elevation locking pins.

Place a level along each gun barrel jacket and adjust each gun in elevation so that the bubble is centered. To elevate the breech end of the gun, loosen the locknut under the aft trunnion and back out the externally threaded bushing that screws into the top of the cast slide. (This leveling is essential, since it establishes a parallel relationship of the guns to the turret ring gear at zero elevation for the turret and elevation unit.)

Toe each gun out laterally as far as possible. To move the guns in azimuth, loosen the locknut under the aft trunnion far enough to permit the eccentric bushing to be rotated. The locknut must be tightened to hold the adjustment.

Insert a boresighting tool (borescope) in the barrel of each gun.

Erect the boresighting screen according to instructions in the maintenance handbook for the type airplane.

Adjust the screen so that the gun targets are at the same elevation as the gun bores, and so that the center line of the screen coincides approximately with the extended center line of the turret.

Move the turret in azimuth so the left gun points to the left of its bull's-eye as far as the right gun points to the right of its bull's-eye. Engage the azimuth clutch.

By means of the aft trunnion adjustments, point each gun exactly on its target. Tighten the adjusting mechanism.

Adjust the elevation of the sight head so that the center of the fixed cross bears on the sight aiming point, or is directly to the right or left of the point. To do this, loosen the locking bolt through the mounting bracket and the sight yoke tube plate and loosen the lock on the elevation adjusting screw, then turn the adjusting screw.

Adjust the sight in azimuth until the center of the fixed cross bears on the sight boresight point. To make this adjustment, loosen the center bolt in the bottom of the mounting bracket and rotate the sighting head to the desired position.

Tighten all locknuts and adjustments and recheck the boresight of both guns and sight.

Ammunition loading.—Assemble four belts of 200 rounds each, and two belts of 35 rounds each using standard M2 links.

Load one 200-round belt in each container with the projectile pointing toward the outside of the curve formed by the container, using care to load two containers for right-hand gun operation and two for left-hand operation.

Note: Ammunition containers are not interchangeable after being loaded for either right gun or left gun operation.

Load the two right gun containers by placing the single cartridge loop end of the 200-round belt on the roller at the upper right corner of the container with the projectile pointing toward the larger curve formed by the shape of the container. Run the belt down the right side to the bottom of the container and along the bottom of the container to the left side. Then stow the remainder of the belt in zigzag fashion, laying the two cartridge loop ends of the belt over the roller at the upper left corner of the container.

Load the two left gun containers in the opposite manner, beginning at the upper left corner with the projectiles pointing toward the larger curve formed by the container, being sure the double-cartridge loop end of the belt points toward the gun.

Install the ammunition containers on the support rails in the turret. Allow the container latches to engage and check the latches, making sure the containers are securely locked in position.

Connect the belts between the two containers on each side by inserting a live round (one on each side of the turret) where the two containers butt together.

Caution: Gun switch must be in OFF position before loading, to prevent personal injury.

Open the back cover of the hinged portion of the booster.

Feed the two 35-round belts up through the chutes, one on each side, with the double link of each belt upward.

Make certain each gun is clear. Insert the free end of each belt into the feed opening in the respective guns, pushing the belt into the gun as far as it will travel. The belt-holding pawl in each gun should hold the belt in place.

Close the hinged door on the booster.

AERO 9 SERIES TURRET

General Description

The Aero 9 series turrets include the 9B–1, 9C, and 9D. This series turret is designed for use in the nose of patrol type aircraft. The turret is inhabited and mounts two 20-mm guns. All the necessary controls for aiming and firing the guns are located within the turret. The turret protects the front of the aircraft from aircraft attacks and provides forward-action fire against small naval craft and ground installations. The turret also serves as a stabilized bombsight platform for low altitude bombing and as a searchlight control station.

Power for movement of the turret is furnished by a Maxson stabilized drive, identical to that used in the Martin 250 series turret. A controller, the internal portions of which are identical, is provided. The controller handles are located between the seated gunner's legs where his hands fall naturally upon them.

Gunner protection is provided by armor plates and bullet-resistant glass. The upper halves of both sides and the front of the turret ball are made of transparent plastic. This provides ample vision for the gunner.

The turret is equipped with a lead-computing sight. Also part of the turret equipment is a trouble light, interphone station box, suit heater receptacle, deck ventilators, gunsight camera, and provisions for oxygen supply. Manual drives are provided for both turret movements.

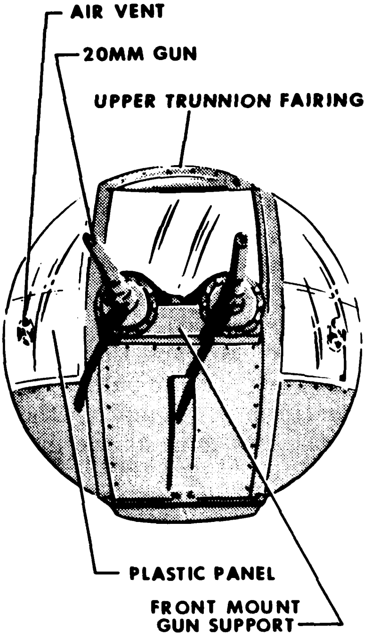


Figure 4—13.—Front view of Aero 9C turret.

The turret ball structure consists primarily of two vertically arranged rings which are secured together at top and bottom by upper and lower trunnions. These rings support two rotating rings on which the remainder of the spherical structure is attached. The upper trunnion is secured to the upper mount assembly through a bearing and shaft and the mount assembly is secured to the aircraft nose section. A bearing and hollow shaft at the bottom of the turret supports the lower trunnion on top of a stationary drive housing. The housing is bolted to the aircraft nose section. This suspends the entire turret ball between the upper support assembly and the drive housing and provides a vertical axis for azimuth rotation. This azimuth movement is obtained by a drive motor which transmits power to the turret through a gearing arrangement, driving a sector gear affixed to the lower trunnion.

The two rings which are affixed to the upper and lower trunnions are on a common lateral axis. The two rotating rings, which support the spherical structure, are held to the fixed rings by a number of plastic balls confined in a channel between the mated rings. Thus, the two rotating rings and all parts of the structure attached to them are free to rotate on the lateral axis of the ball for elevation movement. The elevation movement is obtained by a drive motor which transmits power to sector gears, attached to the rotating rings through a gearing arrangement.

The area between the two fixed rings is spanned at the bottom by a center structure which supports both the gunner and the guns. The rear section of this center structure conforms to the spherical contour of the ball and serves as a seat for the gunner. At approximately the center, the central structure rises vertically and then extends horizontally forward to the front edge of the ball. The horizontal portion serves as a platform for mounting the guns. This arrangement places the two guns at the gunner's chest level when he is seated.

A front gun-mount assembly is located at the front of the center structure. This assembly also provides a means of sealing the front of the turret around the projecting gun barrels. Rear gun mounts are bolted to the vertical section of the center structure.

Above the front gun-mount assembly, the center section is enclosed by a transparent plastic sighting panel. A section of armor plate covers the lower half of the center section. A section of bullet-resistant glass is located between the sighting panel and the gunner. It is mounted in a pivoted frame so that the glass may be lowered to protect the gunner, or raised and stowed out of the way. Spring-loaded latches on each side of the frame lock the glass panel in either the normal or stowed position.

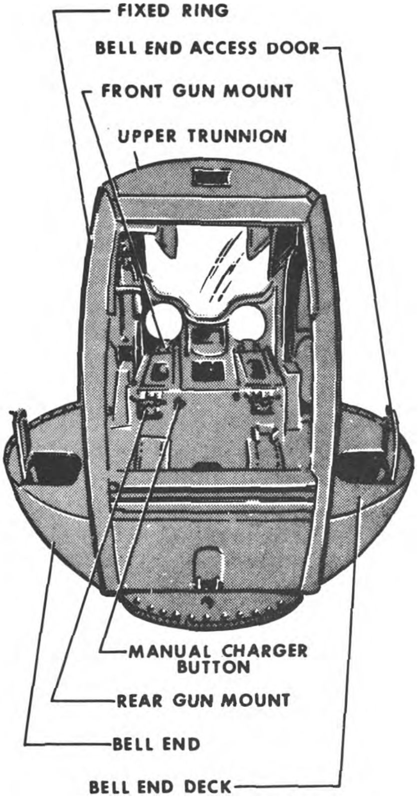


Figure 4–14.—Portion of turret ball from the rear.

The port and starboard sections of the ball consist of end-bells which complete the spherical shape of the turret ball (fig. 4–14). The lower half of each end-bell is formed of sheet metal and encloses a separate compartment where empty cartridge cases and belt clips are deposited. The upper part of each compartment is referred to as the end-bell deck. When the gunner is seated, he places his feet and legs on top of the end-bell decks, straddling the guns and forward part of the center structure.

A canvas seat is stretched tightly over the rear part of the center structure to keep the gunner's body from contacting the metal structure.

Turret Manual Drives

The turret is equipped with mechanical hand drives for moving the turret manually in azimuth and elevation. Hand-operated clutches provide shifting between the end drives and power drives.

AZIMUTH HAND DRIVE.—The azimuth hand drive is directly connected to the azimuth gear train by a flexible drive shaft. The hand drive crank is located aft of the turret in the aircraft nose section (fig. 4–15).

A clutch assembly (10) is incorporated in the azimuth drive gear train. This clutch allows shifting between the azimuth drive motor and the manual drive handcrank (2). The clutch is operated by a lever (1) which is a part of the azimuth hand drive assembly and is connected to the clutch by a flexible wire cable. Placing the clutch lever in the MANUAL position disengages the drive motor from the gear train and engages the manual drive crank with the gear train. Turning the crank moves the turret in azimuth through the same gear train employed for power-driving the turret. Placing the clutch lever in the POWER position engages the handcrank and engages the drive motor. Clockwise rotation of the handcrank results in clockwise rotation of the turret and vice versa.

ELEVATION HAND DRIVE.—A similar hand drive inside the turret ball serves the elevation system. Because of its location, the handcrank of this assembly does not drive through the elevation power drive gear train. It is directly geared to a separate segmental gear secured to the upper section of the port rotating ring. The clutch lever in this assembly is connected by a flexible wire cable with a clutch in the elevation power drive gear train and also operates a clutch in the elevation hand drive assembly. Operation of the clutch lever is the same as that of the azimuth lever. The manual drive gear train clutch is operated by a steel ball that rides against

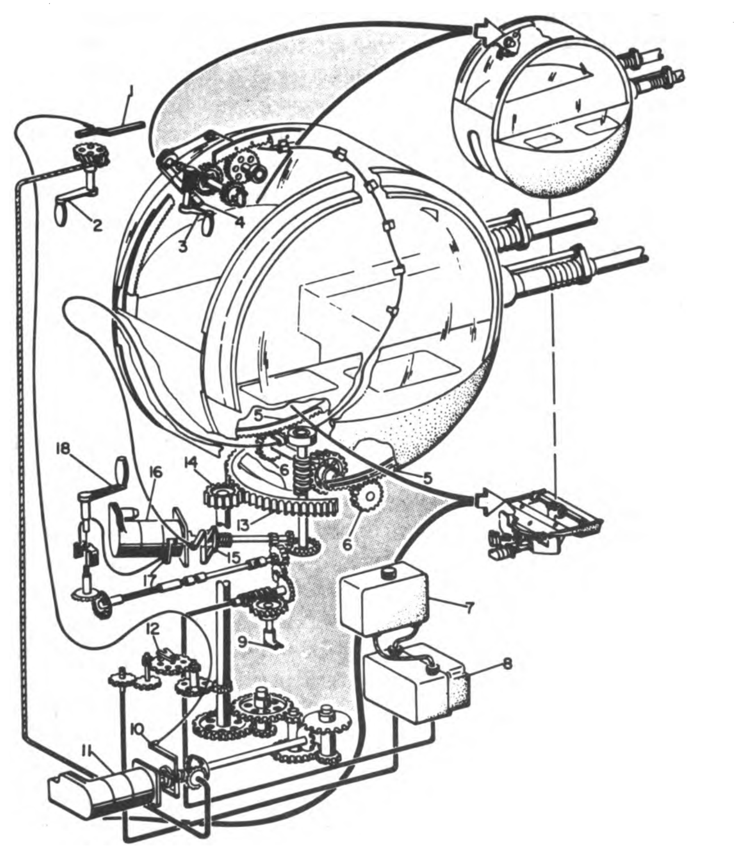


Figure 4–15.—Mechanical drive system.

a flat cam on the end of the clutch lever. When the lever is moved to the MANUAL position, the action of the lever forces the clutch into engagement. Moving the lever to the POWER position permits the clutch to disengage. Both clutches are of the dog type. Usually, during the shifting operation, the clutch being engaged must rotate a fraction of a turn before the dogs become mated.

A second elevation hand drive is mounted in the aircraft nose section. This is an emergency hand drive and has no connection with the elevation hand drive in the turret. The emergency drive is geared directly to the elevation power drive gear train. It contains no clutch to disengage it from the gear train but is operated by a removable handcrank. The crank is normally stowed at the top of the turret near the azimuth hand drive. When the crank is inserted in the guide above the drive and depressed (see fig. 4–15), it engages the drive shaft and releases the brake on the elevation drive motor. Since this drive moves the turret through the power drive gear train, the clutch at the elevation hand drive in the turret must be in the POWER position when the emergency drive is used. The handcrank must be completely depressed and the clutch on the elevation hand drive must be in the POWER position before the handcrank is rotated or damage will occur to the gear box.

Armament System

Each of the two 20-mm guns is equipped with a T2 electric gun heater, an Aero 7A pneumatic gun charger, an M2 feed mechanism, and an M4 electric trigger.

NOTE: If M24 guns are installed, firing is accomplished through use of a synchro switch, instead of the M4 electric trigger.

A special adapter box for the guns is mounted at the bottom of the gunsight mounting bracket. The box contains the relays and circuits for controlling the guns. A camera on-off switch, a left- and right-hand gun circuit breaker, and a reset button are located on the box.

Each gun is secured by a front mount and a rear mount. The front mount consists of a trunnion block and ring which is slotted for engagement with a mating ring and socket fitted into the front gun-mount assembly. The ring on the gun is fixed in position, but the ring in the front gun-mount assembly is designed to be rotated about the common axis of the two rings by operations of a hand lever. The two levers are located at the front of the gun platform on the respective sides of the center section. Each has a red-colored knob and rotates fore and aft, locking the guns in the forward position. Movement of each lever rotates the associated ring in the front gun-mount assembly. Lands in the gun mount lock around similar lands in the ring on the gun, wedging the gun into position in the front gun-mount assembly. Each lever is locked by a spring-loaded pin located at the base of the lever. A rear mount latch is affixed to the breech-end of each gun and is engaged on the underside by the ends of an eccentric bolt of the rear-mount assembly. When two clamping bolts at the upper aft end of the mounting assembly are loosened, the eccentric bolt can be rotated. Rotation of this bolt, by means of the octagon-shaped ends, positions the latch up or down and transmits a small amount of vertical adjustment to the breech-end of the gun. Parallel to and directly aft of the eccentric bolt is another bolt with a yoke, which mates with the eccentric bolt by means of a groove in the eccentric bolt. Rotation of this bolt with the yoke results in a left or right movement of the eccentric bolt, thus transmitting azimuth movement to the guns. The two clamping bolts must be retightened after each adjustment. These adjustments are made during boresighting.

Ammunition for the guns is fed from two ammunition boxes in the nose section. Flexible ammunition chutes carry the ammunition from the boxes into the turret, under the gunner's seat, and upward to the gun platform, looping out into the feed mechanisms on top of the gun receivers. Electrically operated automatic boosters, mounted on the ammunition boxes, assist the feed mechanisms in moving the ammunition at the rate required for proper feeding of the guns. A supply of 400 rounds per gun is carried in the ammunition boxes and chutes.

Empty cartridge cases are expelled from the bottom of the guns through openings in the gun platform. The openings guide the cases into the end-bell compartments below. Link discharge chutes on the outboard side of the guns guide the empty links into the same compartments. The end-bell compartments are divided into two sections by baffle plates. The forward section of the compartment collects the cartridge cases and links. When the turret is elevated, the cases and links pass over the baffle plate into the aft section. They are trapped there by the baffle plate which prevents them going back into the forward section when the turret is depressed. This prevents cases and links from accumulating under the ejection openings and causing the guns to jam. Each of the end-bell compartments store 180 empty rounds.

During full gunnery operation, empty cartridges and links may be dumped into the nose section.

Compressed air for the pneumatic gun chargers is supplied by a small, electric motor-driven, three-stage compressor. The compressor motor operates until a pressure of 1450±50 pounds per square inch has built up. At this time the motor is stopped by a pressure actuated switch.

The guns are fired by the parallel-connector trigger switches at the index finger positions of the controller handles. The circuit is connected so that all switches related to the turret power drive must be closed. The gun's switch must be in the FIRE position and one or both of the trigger switches must be closed to fire the guns.

A Mk 18 Mod 6 gunsight is provided. This is a lead-computing, reflector-type sight designed to compute the point of aim for the 20-mm guns.

Searchlight System

The searchlight system is synchronized with the movements of the turret and is used to illuminate a possible target. Control of the searchlight system may be switched between the navigator and gunner. This is done by the navigator. A foot switch is provided just above the gunner's left footrest. This switch allows the gunner to turn on the searchlight with his foot, provided the toggle switch on the control junction box is in the ON position and the gunner has control of the searchlight. A red light on the gunner's control junction box indicates the gunner has control of the searchlight.

Ventilation System

Gun gas and smoke are carried from the turret ball by means of a ventilation system. This system consists of a manifold, several ventilation holes, and a smoke elimination door. All large openings in the ball are sealed for proper operation of the ventilation system. The manifold is connected to the aircraft heating system through a flexible duct which carries heated air to the rear of the turret ball. This heated air builds up a pressure inside the ball which causes the gun gas and smoke to be forced through the ventilation holes, underneath the ball center section, and into the aircraft nose section through openings at the rear of the turret ball. The smoke elimination door is automatically opened when the gun switch is moved to the FIRE position. This allows the gun gas and smoke to be forced through it and out of the aircraft nose section. The canvas door at the rear of the ball and the entry door into the aircraft nose section must be closed to make the ventilation system effective. A butterfly valve in the manifold allows the gunner to regulate the amount of air entering the turret ball.

Maintenance

CLEANING.—Much trouble will be averted by taking every possible precaution to prevent dirt, dust, or other foreign material from coming into contact with vital working parts of the turret. Turret units and parts will collect much less dust if oil and grease deposits are removed at the regular inspection periods.

Remove dirt, mud, and grease from the outer surface of the turret skin and both inside and outside of all transparent plastic sections and the bullet-resistant glass. Warm water and soap (Specification C–120) is recommended, but cold water may be used if warm water is not available. When washing the turret skin, avoid using too much water, since considerable damage can be caused if water is allowed to drain into operating units.

If oil deposits are difficult to remove, wash the surface with naphtha (Specification AN–N–3) and rinse with clear water. If naphtha is not available, use ordinary hexane.

NOTE: Use only the above mentioned cleaners for cleaning the transparent plastic sections. Avoid excessive polishing of plastic sections.

The inside of the turret can be cleaned with ordinary vacuum cleaning equipment. This method picks up dust and loose material without danger to equipment. If vacuum cleaning equipment is not available, use cloths moistened with an approved cleaning solution and carefully wipe dust and other accumulations from operating units and structural parts. Never use gasoline for cleaning inside the turret or nose section. Do not use carbon tetrachloride for cleaning plexiglas enclosures, since this solvent causes crazing of the enclosures.

Clean exposed gears with a brush that has been moistened with kerosene. After cleaning, coat the exposed sectors and gears with grease (AN–G–3) to protect them from rust and corrosion.

BORESIGHTING THE GUNS.—Level the airplane and position the turret at zero azimuth and zero elevation.

Position a boresighting screen approximately 1,000 inches in front of the turret.

Turn the MASTER switch to BORE, then check to see that the sight switch is also set to BORE.

Turn the selector switch lever on the sight control box panel to the position marked FIXED.

Adjust the selector-dimmer knob on the sight control box panel until the fixed cross reticle (fig. 4–16) appears clearly defined on the combining glass of the sighting head.

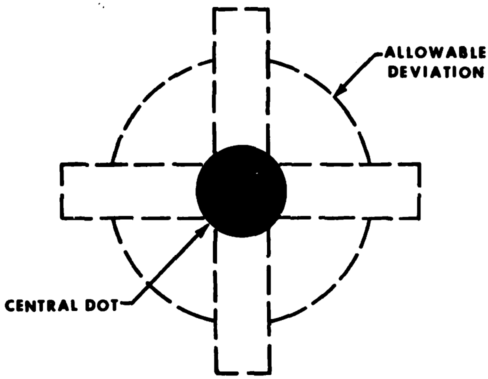


Figure 4–16.—Correct alignment of fixed cross and gyro reticle pip.

While sighting through the sighting glass, have a second operator raise or lower the boresight screen until the sight spot on the screen is exactly level with the line of sight.

Continue sighting to keep the sight spot level with the line of sight and further adjust the screen to make the horizontal line between the two gun spots exactly level.

Insert a boresighting tool (borescope) into the bore of the port gun.

Sight through the borescope and simultaneously adjust the rear gun mount to position the gun vertically so that the bore of the gun is level with the horizontal line between the two gun spots on the screen. The rear mount is adjusted vertically by means of the eccentric bolt at the forward part of the mount. This adjustment will move the rear end of the gun up or down the slight amount necessary to place it in true alignment with the line of sight and the center lines of the turret and airplane.

Adjust the rear gun mount of this same gun so that the rear mount latches (attached to the gun) are at approximately the center position of the gun mount. Lateral adjustment of the mount is made by rotating the aft bolt in the gun mount, which can be rotated when the upper two mounting bolts of the mount are loosened. Rotation of the bolt moves a traveling pawl from side to side between the bosses of the gun mount, and this pawl carries the eccentric bolt, gun latch, and gun with it.

Sight through the borescope attached to the port gun and have a second operator move the boresight screen to the right or left, as necessary, to align the gun bore with the port gun spot on the screen.

NOTE: The vertical adjustment of the boresight screen must not be altered during this procedure. After the port gun is properly aligned with the port gun spot, a final check should be made to ascertain that the horizontal line on the screen is still level. The screen is now in final position for completing the boresighting, and must not be moved again.

Move the borescope to the starboard gun. Sight through the borescope and adjust the rear mount vertically and laterally so that the aligned gun bore is aligned with the desired target spot on the screen.

Recheck the alignment of both guns, then securely lock all rear gun mount adjustments by tightening the upper two mounting bolts on each mount.

With the gun bores still aligned on the respective spots on the screen, adjust the sighting head in azimuth until the center of the fixed cross of the reticle is in lateral alignment with the sight spot on the screen.

Tighten the sight attaching screw that locks the adjusting rings, then recheck this adjustment for accuracy.

NOTE: As the sight was correctly aligned in elevation at the beginning of this procedure, the sight and both guns should now be correctly aligned with the respective target spots on the boresight screen. However, the use of the fixed cross reticle of the sighting head as a reference point for harmonizing the sight will only produce accurate results when the fixed reticle and the gyro reticle are in correct alignment. That is, the gyro reticle pip must be superimposed upon the fixed cross, when both reticles are lighted simultaneously.

To check the sighting head for correct alignment of the gyro and fixed reticles, turn the selector switch lever to the position marked FIXED AND GYRO.

Sight through the combining glass at the sight spot on the screen to note whether or not the gyro reticle pip is accurately superimposed upon the fixed reticle cross. If the two reticles are not correctly aligned, the sighting head must be readjusted in accordance with instructions contained in the proper sight handbook.

Loading ammunition.—Ammunition belts are made up separately for left-hand and right-hand guns. (See fig. 4–17.) Select the correct ammunition belt for the guns to be loaded.

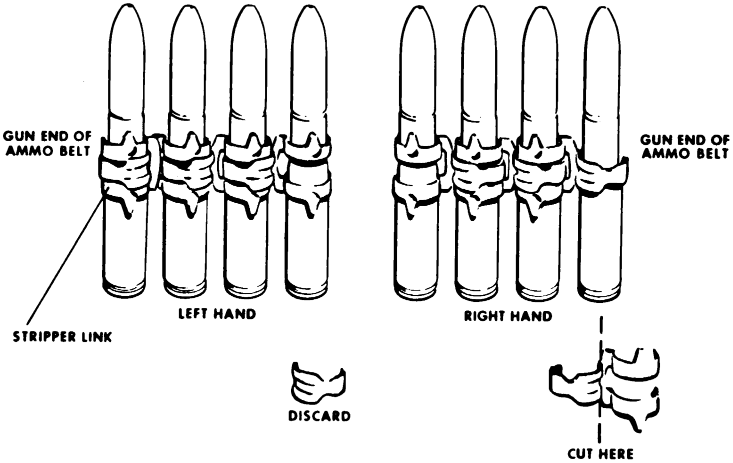


Figure 4—17.—Forward ends of ammunition belts.

Fold the ammunition belt into the proper ammunition box until it is full. Before engaging the first rounds in the booster mechanism, it is important that the following modification be made to the forward ends of the ammunition belts. Remove the leading link from the belt and cut the link, as shown in the right-hand drawing of figure 4–17. Dress the burred edge to insure flexibility of the link. Engage the stripped link with the flange of the second link, so that the leading edge is now in the opposite direction. Insert the cartridge in the modified link. The modified belt end is shown in the right-hand drawing of figure 4–17. Push the forward end of the ammunition belt into the mouth of the booster.

Station one ordnanceman in the turret ball and another man in the aircraft nose section adjacent to the booster.

Depress the proper LOAD switch on the main junction box to actuate the booster and move the belt forward through the chute. Watch the progress of the belt carefully, so as not to jam the forward end of the belt into the feed mechanism on the gun. When the forward end reaches the feed mechanism release the LOAD switch.

Engage the first round of the ammunition belt with the teeth of the sprocket in the feed mechanism, then use the socket wrench furnished with the feed mechanism and force the first round of ammunition into the gun receiver. No damage to the feed mechanism will result from excess winding, since the torque stabilizer action of the feed mechanism protects the spring from overloading. Wind the feed mechanism clockwise on the starboard gun and counterclockwise on the port gun.

QUIZ

1. Turrets were first used by the
   a. British
   b. French
   c. Germans
   d. Americans

2. The forerunner of the modern aircraft turret was the
   a. outer ring
   b. collector ring
   c. hook ring
   d. Scarff ring

3. Upon seeing the designation Martin 250 CE 326, you would know that the turret
   a. mounted two 20-mm guns
   b. was hydraulically operated
   c. belonged in a TBM-3
   d. was cylindrical in shape

4. The purpose of the stabilization system on the Martin 250 CE turret is to compensate for
   a. sight movement
   b. aircraft movement
   c. target movement
   d. turret movement

5. The collector ring on the Martin 250 CE turret is used to
   a. mount turret in aircraft
   b. hold the down roller assembly
   c. bring power to turret
   d. mount turntable in outer ring

6. The turntable on the Martin 250 CE turret is held in place by rollers to the
   a. turret frame
   b. aircraft
   c. collector ring
   d. outer ring

7. The gun cradles on the Martin 250 CE turret are geared to the
   a. controller
   b. generator
   c. profile interrupter
   d. torque tube

8. The main junction box on the Martin 250 CE turret is located
   a. under the gunner's seat
   b. in front of the gunner
   c. left side of gunner's seat
   d. back of the gunner's seat

9. When operating the 250 CE turret manually, the guns may be fired by depressing the
   a. action and trigger switches
   b. emergency electrical trigger switch on the elevation handcrank
   c. trigger switches on the controller
   d. emergency electrical trigger switch on the azimuth handcrank

10. The function of the motor generator on the Martin 250 CE turret is to provide voltage to the
   a. prime mover
   b. drive motors
   c. transmitters
   d. stabilization system

11. The correct output for the motor generator unit of the Martin 250 CE turret is
   a. 27.5 volts
   b. 24 volts
   c. 25.7 volts
   d. 115 volts

12. Mounted on the controller are
   a. action switches, trigger switches, and limit switches
   b. action switches, microphone switches, and trigger switches
   c. trigger switches, microphone switches, and limit switches
   d. limit switches, action switches, and microphone switches

13. The drive motors of the Martin 250 CE turret are rated at
   a. 1 horsepower
   b. 2 horsepower
   c. 2.5 horsepower
   d. 2.75 horsepower

14. The transmitters on the Martin 250 CE turret are geared to the
   a. generators
   b. receivers
   c. drive motors
   d. torque tube

15. The azimuth gear box on the Martin 250 CE turret provides mechanical linkage between the azimuth motor and the
   a. gun cradle
   b. ring gear
   c. turntable
   d. torque tube

16. If the guns on the Martin 250 CE turret strike the aircraft, the gunner reports a defective
   a. action switch
   b. structural interrupter
   c. profile interrupter
   d. master relay

17. What prevents the gunner from firing into his own aircraft on the Martin 250 CE turret?
    a. Structural interrupter
    b. Compensator
    c. Mechanical stops
    d. Profile interrupter

18. All of the component units of the drive system, except the gyros, may be cleaned with
    a. carbon tetrachloride
    b. soap and water
    c. vacuum cleaner
    d. compressed air

19. The guns and sight of the Martin 250 CE turret must always be boresighted
    a. prior to each flight
    b. on each 30-hour check
    c. after cleaning the guns
    d. when installing or replacing guns

20. Total ammunition capacity of the Martin 250 CE turret is
    a. 200 rounds
    b. 400 rounds
    c. 800 rounds
    d. 870 rounds

21. Before loading ammunition in the Martin 250 CE turret, be sure that the
    a. gun switch is off
    b. master switch is off
    c. power switch is off
    d. loading switches are off

22. Turrets of the Aero 9 series are always found in the
    a. tail position
    b. nose position
    c. waist position
    d. upper deck position

23. Power for movement of the Aero 9 series turret is furnished by a
    a. Martin stabilized drive
    b. Maxson amplidyne drive
    c. Maxson stabilized drive
    d. Martin amplidyne drive

24. The Aero 9 series turret is driven by manual or
    a. electric-hydraulic power
    b. electric power
    c. hydraulic power
    d. pneumatic power

25. The azimuth drive motor on the Aero 9 turret is geared to the
    a. rotating rings
    b. torque tube
    c. sector gear
    d. fixed rings

26. The rotating rings and the fixed rings of the Aero 9 turret are held together by
    a. the elevation gear box
    b. plastic ball bearings
    c. steel ball bearings
    d. rivets

27. When M24 guns are installed in the Aero 9 turret they are accompanied by
    a. a synchro switch
    b. an M4 electric trigger
    c. percussion type ammunition
    d. manual triggers

28. Each gun mounted in the Aero 9 turret carries a supply of
    a. 800 rounds of ammunition
    b. 500 rounds of ammunition
    c. 1,000 rounds of ammunition
    d. 400 rounds of ammunition

29. The guns on the Aero 9 turret are charged
    a. electrically
    b. hydraulically
    c. pneumatically
    d. manually

30. The searchlight controls in the Aero 9 turret are located
    a. above the gunner's left footrest
    b. on the gunner's left footrest
    c. on the controller
    d. above the gunner's right foot

31. The transmitters on the Aero 9 as in the Martin 250 CE turret are
    a. shunt type generators
    b. series wound generators
    c. permanent magnet generators
    d. compound wound generators

32. Ammunition for the guns of the Aero 9 turret is carried
    a. in the end-bells
    b. on the deck of the turret
    c. in the nose section of the aircraft
    d. in the tail section of the aircraft

33. The smoke elimination door of the turret ventilation system is controlled by the
    a. action switches
    b. gun switch
    c. thermal switch
    d. main power switch

CHAPTER 5

ELECTROHYDRAULIC TURRETS

GUN TURRET AERO 11 SERIES AND MODIFICATIONS

Description

The Aero 11 series gun turret is designed as a tail turret for use in the P2V, P5M, and similar type aircraft. (See fig. 5–1.) Two 20-mm guns are mounted in the turret which has sufficient movement in azimuth and elevation to provide a cone of fire adequate for protection against fighter aircraft. It also has excellent rear action agressive fire against small naval craft and ground installations.

Although the Aero 11 series and its modifications are classed as a locally controlled type, the gunner's position does not move with the turret ball. (See fig. 5–2.) The actual turret, in which the guns are mounted, is a spherical enclosure. The gunner sits forward of and above this turret ball (using the aircraft's nose as a reference point) in the compartment

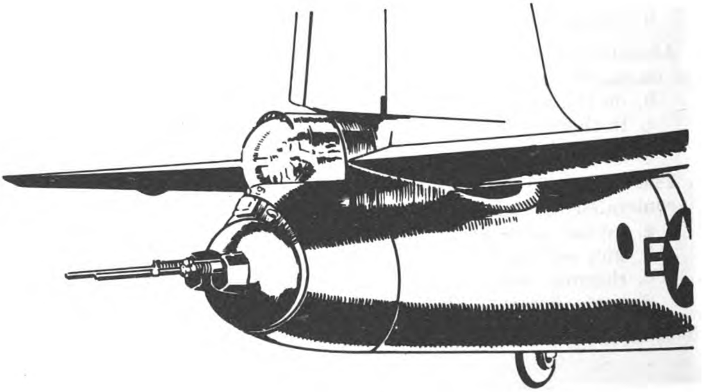


Figure 5–1.—Aero 11A turret. Three-quarter view.

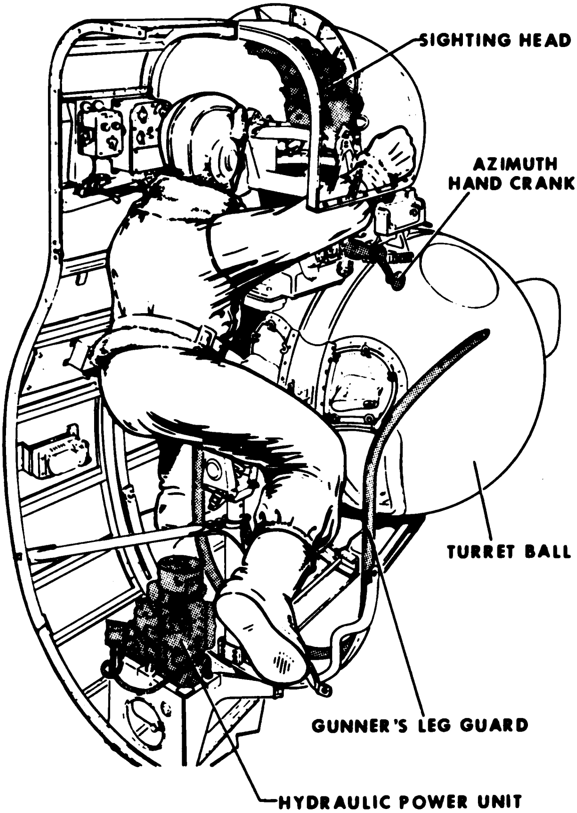


Figure 5–2.—Aero 11A turret showing location of the gunner.

which forms the tail of the aircraft fuselage. The gunner remains stationary while the spherical enclosure containing the guns moves about in azimuth and elevation. The sighting head is geared to the turret ball movements. The gunner is insulated from much of the noise and shock of the firing by the ball enclosure. He is also able to better scan the sky and water around him through the large transparent canopy which encloses him from about the waist up on all sides except the back.

Complete fire control is provided by a twin grip control handle directly in front of the gunner. Each grip contains an action switch and a trigger switch. Turret movements are guided by manipulation of the twin grips. Either or both grips may be used to direct the guns. The neutral position of the guns places them parallel to the center line of the aircraft, pointing directly aft.

Power for the movement of the turret is furnished by the Vickers hydraulic units within the hydraulic power assembly (fig. 5–3). These units are operated by solenoids connected to potentiometer controls in the control handle. This power source and its power controls provide an exceptionally fluid, precise, and sensitive gunpointing mechanism. Manual drives are provided for special uses, such as service work and moving the turret ball during boresighting, and during emergency conditions as a result of power failure.

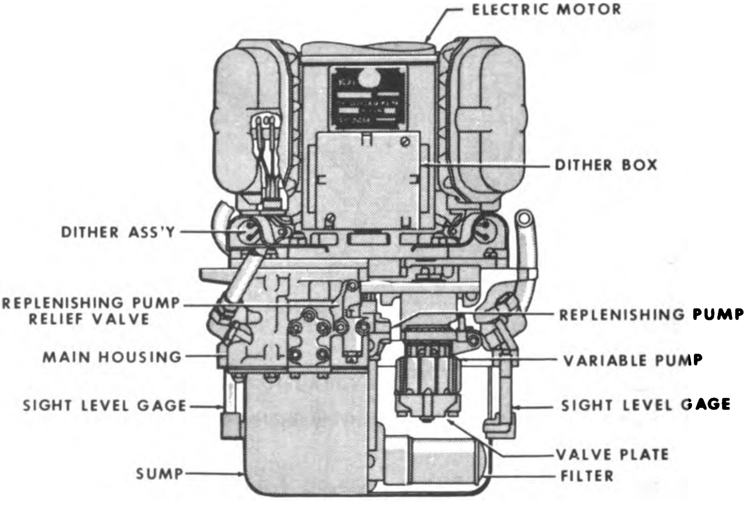


Figure 5–3.—Vickers double hydraulic pumps.

The Mk 18 lead-computing gunsight is part of the turret equipment. (This sight is covered in chapter 6.) Two large ammunition boxes provide a supply of 20-mm ammunition for the guns. Provisions are also made for dumping the empty shell cases overboard, in order that they do not become a storage problem. The 20-mm guns are fired by gun-firing solenoids. They are charged by hand.

The gunner's suit heater connection to the power supply is independent from the turret supply. Provisions are made for this supply as well as in intercommunication station box, and a trouble light in the gunner's compartment. The gunner has no trouble in gaining access to the turret control position since there are no small doors or openings through which he must crawl. The turret forms the aft portion of the aircraft fuselage when installed.

Installation

The installation of the Aero 11A turret (with its associated Mk 18 gunsight system) should be accomplished in accordance with established procedures in order to protect the precision equipment composing the turret. When properly fitted, the installation will show correct alignment with the fuselage and the equipment will work satisfactorily. The boresight procedure and harmonizing of the gunsight should be accomplished only after installation of the turret is completed.

It is never advisable to attempt to remedy any internal troubles in the gunsight while it is installed in the turret. Only obvious and minor corrections should be made. A more deep-seated discrepancy is cause for removal of the sight unit for repair by the authorized activity.

A suitable sling and hoisting equipment is required in hoisting the tail mount and turret into position, and in removal of the tail section. It should be remembered that inadequate equipment can cause considerable damage to the turret and its components. (See fig. 5–4.)

Only one specialized tool is required for the turret. This tool is a long-handled wrench used to give proper spring tension to the ammunition feed mechanism of the 20-mm guns.

NOTE: Instructions on the right-hand ammunition box refer to airborne loading only.

To install the turret, locate the aircraft in a position accessible to the hoisting equipment. After removing the small cover plate from the jack pad, place the aircraft jack against the jack pad and raise the tail of the aircraft sufficiently to hold it steady while the installation is being made. If this is the original installation of a turret, the tail section of the aircraft will have to be removed at the proper aircraft fuselage station. If, on the other hand, the installation is to replace another turret, the old turret must first be detached. When removing the tail section, attach a suitable sling and

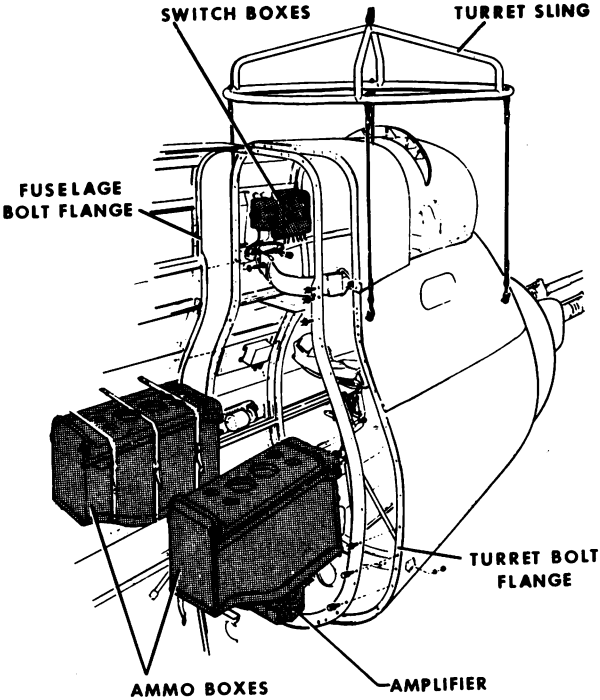


Figure 5–4.—Turret in sling ready for installation.

be sure to disconnect the two taillights. When removing an old (or damaged) turret, disconnect all electrical power wires leading from the turret section. Also remove the taillights and intercommunication cable, and ammunition chutes from the ammunition boxes. Fold all hanging leads and materials into the turret so that they will not foul other parts while swinging the turret from the aircraft.

Inspect the aircraft mounting flange for loose rivets, broken stiffeners, and warping of a flange. If distortion is present in the fuselage flange as a result of an accident or other source of undue force, the tail section of the aircraft must be completely reconditioned. This is necessary to provide a flat and substantial mounting surface for the turret. Check the ammunition box flanges to insure that they are not out of shape. It is not imperative to remove the 20-mm guns from the turret during its installation or removal.

However, the added weight of the guns makes it somewhat more difficult to manage, especially in aligning the turret flange with the aircraft mounting flange.

Caution: Insure that all electrical cables, chutes, and electrical leads have been temporarily folded inside the turret fairing. Any such element allowed to hang over the mounting flange surfaces will be damaged during installation as well as interfere with the installation procedure.

Insure that all mounting bolts have been removed from the holes in the mounting flanges. When the turret and aircraft are ready for installation, pick up the turret with the sling and hoist and maneuver the entire assembly so that the turret mounting flanges are aligned with the mounting flanges of the aircraft. (See fig. 5–4.) Swing the turret slowly into place and insert at least two flange bolts. With the turret in this position, determine if there will be any unusual mounting and fitting problems. The mounting flanges should be properly shimmed according to the pertinent installation instructions. A long tapered punch may be used to advantage to aid in aligning the bolt holes when slight variations occur between the two flanges. All mounting bolts must be high-strength aircraft-type bolts of the correct length. They must be run up tight, but not overtightened as this will materially weaken the bolts.

With the hoist and sling still supporting the major portion of the turret's weight, install the remainder of the flange bolts and tighten evenly. When the bolts are all tightened, unhook the hoisting sling and carefully move the hoisting equipment out of the way. Install the amplifier directly under the right-hand (from the turret position) ammunition box channel. It is mounted in an inverted position and bolted in place. (See fig. 5–4.)

Connect the electrical lead from the turret to the amplifier. Then connect the AN plug from the amplifier to the turret junction box. Connect the two taillights which are located on the turret skin at the rear of the canopy base.

Next, connect the AN intercommunication cable to the new intercommunication box in the turret. If the turret is a different modification from the one being replaced, it may be necessary to remove the old intercommunication junction box. Install the two ammunition boxes in their channels. These channels are equipped with stop brackets which serve to locate the aft ends of the ammunition boxes during installation.

When the installation is complete, check the operation of the turret by performing the items shown on the checkoff lists of the installation instructions. The major item in these lists is the operation of the turret within its limits of contour at a slow rate of speed to insure that the antiference mechanism is working properly. Check the high-speed operation of the turret ONLY after the slow-speed check has been performed satisfactorily, and the other operational checks have been accomplished. When the operation of the turret is satisfactory in all respects, install the two 20-mm guns and their charger systems.

INSTALLATION OF THE 20-MM GUNS.—New 20-mm guns are normally shipped with the feed mechanism installed for left-hand feed of the ammunition. When installing the two guns in the Aero 11A turret, one of them will have to be converted to right-hand feed. Also, if the charging mechanism shipped with the guns is not the type used in this turret, these chargers will have to be removed and the proper type installed.

To install the gun cradle body on the gun mounts, slide the cradle assembly over the gun so that the recoil rollers at the rear of the cradle body engage in their proper guides. (See

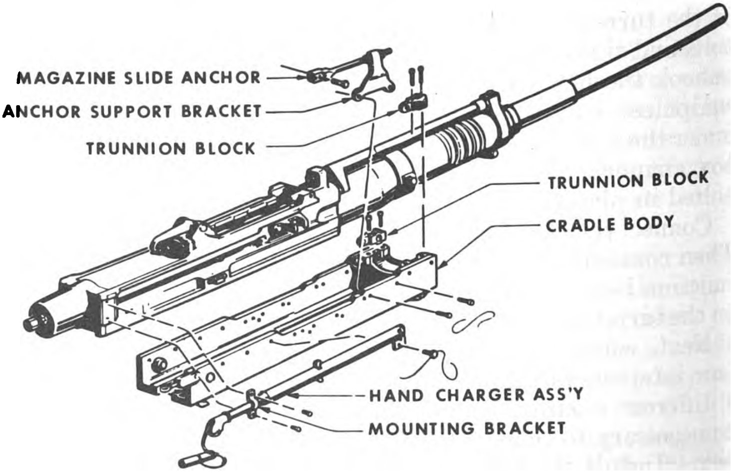


Figure 5–5.—20-mm gun (M3) and its mounting parts.

fig. 5–5.) Install both magazine slide anchors on the anchor support brackets by sliding the anchor support brackets over the ends of the magazine slide anchors. Start the nuts on each of the magazine slide anchors but do not tighten them. Align the anchor support brackets with the holes in the cradle body and insert the two setscrews to hold each support bracket in place. Tighten and safety wire them to each other. Install the front gun mount (fig. 5–6) on the cradle body. Be sure to use high-strength cap screws for this, and safety wire them securely.

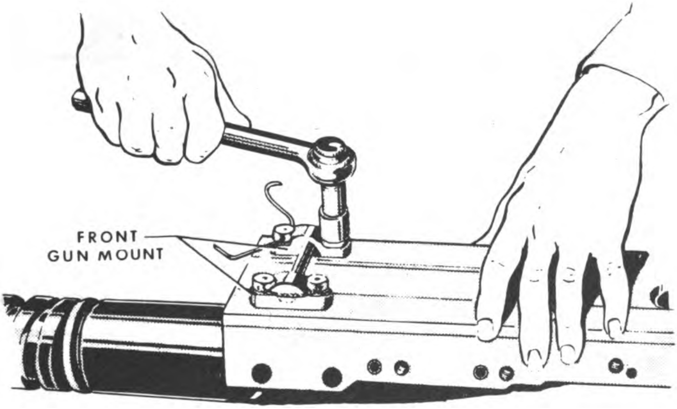


Figure 5–6.—Installation of front mount.

Warning: Attach front gun mount to guns with the milled flats on the cross pin facing the butt end of the guns. Reversal of front gun mount will prohibit secure installation of the guns in the turret and may damage the gun mount locking mechanism.

Install the two rear gun mount anchors (fig. 5–7) on the cradle body with two hex-head cap screws at the rear and the two flathead screws at the front. The guns are now ready for installation in the turret. Insure that both front gun mount control handles are in good working order. One control is connected to the pawl of each front gun mount to hold the gun in place. These pawls are spring-loaded and have a definite snap action when operating properly. Coat sparingly with the specified grease the recesses of the front gun mounts and the slides of the rear mounts. Next, release

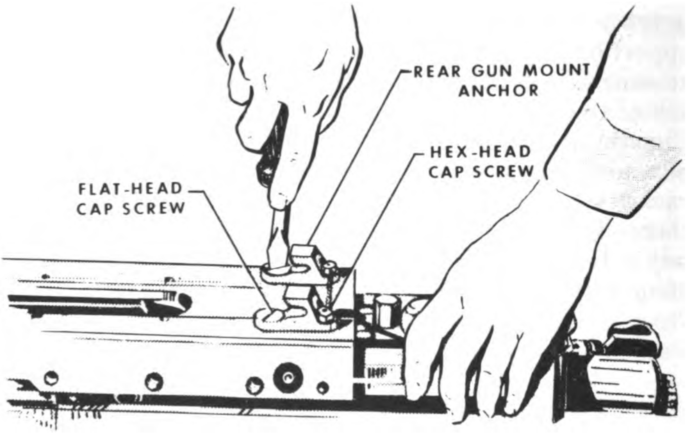


Figure 5–7.—Installation of rear gun mount.

the elevation hand control handle and depress the guns about 20 degrees. Slide the gun carefully through its access cover opening. Carefully manipulate the gun on its mount until the slider on the gun engages the track in the rear mount. Push the gun forward vigorously until the front mount is engaged and the pawl snaps into its locked position. Do not use foot to snap locking handle. The gun is now ready for use with the exception of attaching the various accessories in the Aero 11A turret. This installation description is based on the M3 20-mm gun.

Operation

The operation of the Aero 11A turrets is controlled from a position outside of the actual ball which houses the guns. The Mk 18 lead-computing gunsight is mounted outside the ball in the gunner's compartment. It is attached to the elevation and azimuth controls through a system of gears. This gear system keeps the gunsight head and the guns harmonized in operation throughout the entire cone of fire.

Azimuth drive.—The ball portion of the Aero 11A turret is mounted vertically on two trunnion (ring) bearings which are at right angles to the fore and aft center line of the aircraft fuselage. (See fig. 5–8.) The turret is rotated on these trunnions by an azimuth gear train which transmits the mechanical rotation from the azimuth drive hydraulic motor to the final azimuth drive pinion which is meshed with the gear sector. This gear sector is attached to the turret ball and moves the ball in either direction in azimuth in response to the azimuth pinion rotation. There are no mechanical limit stops for controlling the limit of the turret rotation. Instead, the turret ball is limited in its rotation by a mechanically controlled limit system. This system receives its control factors from the antiference mechanism (fig. 5–9) located directly below the hand control unit. The antiference mechanism returns the potentiometer wiper arm to the center position, thereby stopping the turret.

Elevation drive.—The elevation movements of the turret are entirely independent of the azimuth movements. The

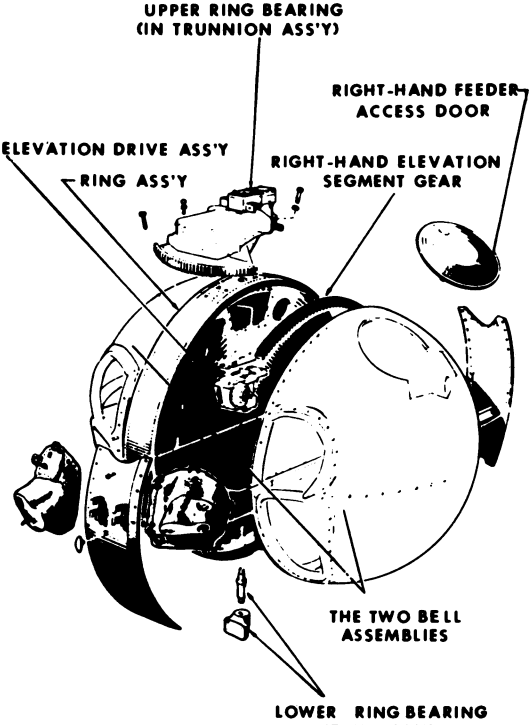

UPPER RING BEARING (IN TRUNNION ASS'Y)
RIGHT-HAND FEEDER ACCESS DOOR
ELEVATION DRIVE ASS'Y
RING ASS'Y
RIGHT-HAND ELEVATION SEGMENT GEAR
THE TWO BELL ASSEMBLIES
LOWER RING BEARING (TRUNNION)

Figure 5–8.—Turret ball halves of the mount assembly.

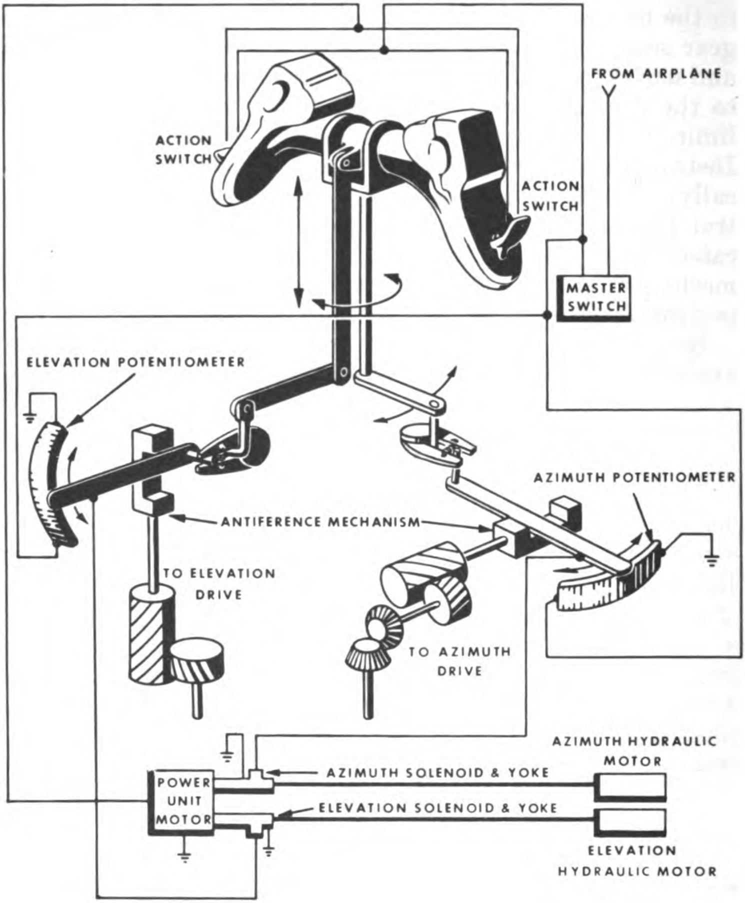


Figure 5–9.—Hand control and antiference mechanism schematic.

two end-bells of the turret ball (figs. 5–8 and 5–10) are held to the circular center structure (ring assembly) by two complete rows of plastic ball bearings. These bearings roll in races which mate with the races of the ring assembly. The structure is, in turn, held to the turret by the two azimuth trunnions. The two end-bells are made to rotate together as a single unit by two elevation drive pinions mounted on the same shaft. The elevation drive pinions are driven by a hydraulic motor through a series of accurately meshed gears.

Each of these drive pinions engages a segment gear which is bolted to its respective half of the turret ball. The turret ball is thus moved in elevation in direct response to the movements of the elevation drive motor. This motor is controlled by the turret control handles. Limits of movement in elevation of the turret ball are controlled by the antiference mechanism in the same manner as described under the azimuth drive.

Since the azimuth and elevation movements of the turret ball are completely independent, the ball may be moved in elevation without moving in azimuth. It may also be moved in azimuth without moving in elevation. Any angular displacement of the control handle will cause rotation of both elevation and azimuth hydraulic motors, and thus move the turret in an augular direction. This system provides a means of displacing the guns in any desired angular direction within the azimuth and elevation range limits.

The LIMIT CONTROL (antiference mechanism) causes the turret ball to be limited (stopped) at the outer sector of the cone of fire through an electrical circuit to the azimuth and elevation solenoids. (See fig. 5–9.)

The turret is operated and controlled by three fundamental systems: an electrical system, a hydraulic system, and a mechanical system. The sensitive follow valves in the hydraulic system, which actually provide a motive power for the operation of the turret, are controlled by electrical signals. The strength of these signals is determined by the control handle position, or the degree of deflection from neutral. These signals are amplified by the electrical amplifier to increase the current controlling the hydraulic control valves. Increasing the current is necessary to insure positive response of the hydraulic follow valves to changes in the control handle deflection.

The hydraulic system, which obtains its motive power from the four-horsepower constant-speed electric drive motor, is controlled by the electrical system. Hydraulic pressure, in turn, produces rotation of the two turret drive motors. The elevation and azimuth drive motors operate the turret ball through mechanical gear trains which are connected directly to the elevation and azimuth hydraulic motors, respectively. (See fig. 5–10.) Each of these fundamental systems of operating the turret is directly and indirectly controlled by the

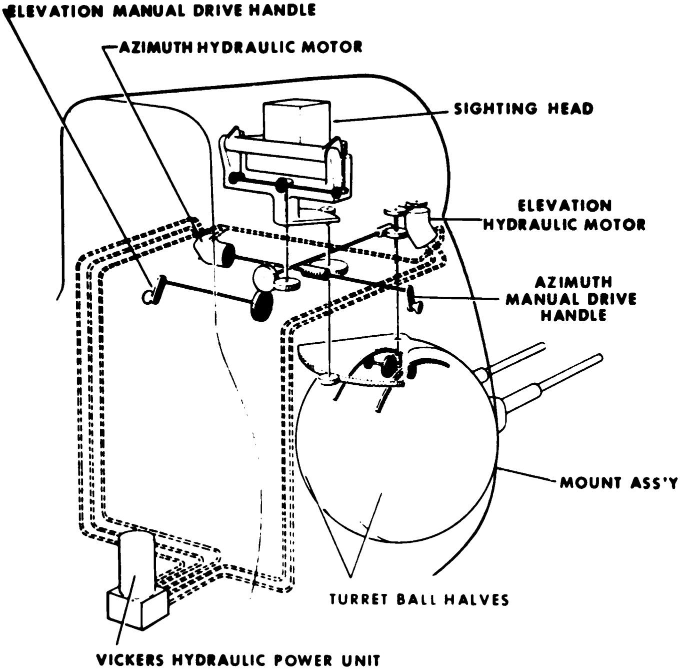

ELEVATION MANUAL DRIVE HANDLE
AZIMUTH HYDRAULIC MOTOR
SIGHTING HEAD
ELEVATION HYDRAULIC MOTOR
AZIMUTH MANUAL DRIVE HANDLE
MOUNT ASS'Y
TURRET BALL HALVES
VICKERS HYDRAULIC POWER UNIT

Figure 5–10.—Turret drive schematic.

sensitive valve mechanisms and later modified by the amplification systems. This results in turret operation which is completely responsive to all control handle movements.

Manual operation.—There are times when the turret can be positioned more effectively by hand than by power operation. Therefore, for servicing and certain other operations, handcranks are geared directly by mechanical connections into the azimuth and elevation systems. (See fig. 5–10.) Each handcrank is connected with its respective drive system by means of a small power clutch. This clutch may be disengaged by holding the crank handle toward its respective drive housing as the crank is being rotated. Each clutch is so constructed that when the handcrank is not connected, the clutch will be automatically engaged. This provides a direct mechanical connection between the hydraulic drive motor and the drive pinion of its respective movement.

Hydraulic power system.—The Aero 11A turret is operated by an electric motor driven hydraulic power system. In order to understand how this system functions, it is necessary to have an understanding of some of the fundamental principles of hydraulic power transmission.

The power system is used for converting a constant-speed mechanical rotating motion into hydraulic power and reconverting it to mechanical motion in order to perform the required work. A special hydraulic fluid is pumped by the hydraulic system which is driven by a constant-speed electric motor. This fluid is carried through tubing. Tubing may be installed in locations where mechanical drives and linkages would be entirely impractical.

GENERAL OPERATING PRINCIPLES.—The hydraulic pump, which is driven by a constant-speed motor, will deliver a given quantity of fluid as long as it is being driven at a constant speed. Assume that the fluid is transmitted from a pump through a line which must be of sufficient size to carry the volume of fluid freely from the outlet port of the pump back to the inlet port. Fluid will continue to be circulated as long as the pump is being driven. There will be no appreciable pressure in the lines due to the fact that there are no restrictions in the lines to offer resistance to the fluid flow. The only factor for increasing pressure is the frictional resistance offered by the inner surfaces of the tubing. If a restriction, such as an adjustable valve, is deliberately placed in the line and partially closed, it will reduce the free flowing condition in the line.

Pressure will then immediately be created between the outlet port and the restriction. Pressure will be increased because the fluid is not compressible and the same given quantity of fluid will be trying to flow through a smaller opening. Therefore, the pump must exert a greater pressure on the fluid in order to force it through this smaller opening.

The pressure that has been created is potential hydraulic power. This hydraulic fluid pressure is used to drive the hydraulic motors. If it were possible to increase the speed of the electric motor, more fluid would be delivered by the pump. Assume that this has been done, and the same restriction kept in the line. The pressure would increase because of the higher pressure created as a result of the greater volume. If the valve were opened slightly, the pressure would drop. If the valve were closed completely, the motor would probably stall, or the lines would rupture. Hydraulic pressure may be controlled in two ways: by varying the restriction offered to the hydraulic fluid, or by varying the volume delivered by the pump. In a constant-speed motor driven system, the only method of varying the control is to vary the resistance offered the fluid flow.

The electric motor driven pumps used in the Aero 11A turrets, together with their controls, are contained in a single unit known as the HYDRAULIC POWER UNIT. (See fig. 5-11.) This unit is located at the base of the fairing directly behind the turret ball. The four-horsepower motor operates at constant speed, but pump displacement is variable. This means that the volume delivered by the pump is variable. This also

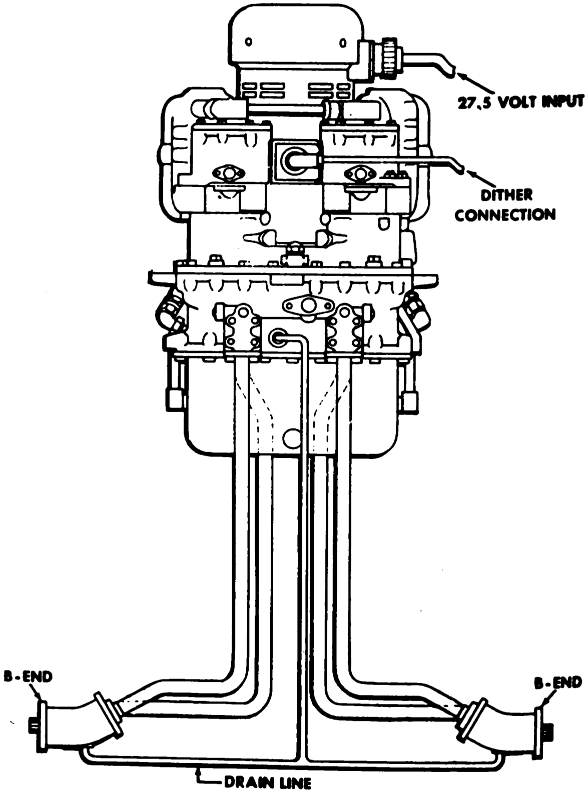


Figure 5-11.—Hydraulic power unit.

means that the volume delivered by the pump may be increased or decreased as required. There is an additional feature which permits the direction of fluid flow to be reversed when desired. The self-contained power unit has two identical hydraulic pumps of the piston displacement type; one located in the azimuth hydraulic system, the other in the elevation hydraulic system. Both pumps are driven by the one electric motor. The fluid from the pumps is delivered by tubing to two piston-type hydraulic motors and then returned to the pumps. The hydraulic motors are fixed-displacement motors requiring a definite amount of fluid for each revolution. Because the hydraulic motors are the fixed-displacement type, the variation of the volume and direction of the fluid flow from the pumps varies the speed of the hydraulic motors and controls their direction of rotation.

In any hydraulic system, a small amount of hydraulic fluid will get past the operating parts of the pumps and motors as they rotate. This is due to the operating clearances that must be allowed between the working parts in order to prevent excessive friction. This passage of fluid is known as "hydraulic slip." A small quantity of replacement fluid is constantly needed to keep the main pumping circuit full. Fluid replacement is accomplished by means of a REPLENISHING PUMP (fig. 5–12) which operates at considerably lower pressure than the regular hydraulic pump. This replenishing pump is driven by the main electric motor. It delivers fluid into the low pressure side of the hydraulic line, keeps the circuit full, and eliminates any bubbles or gaps in the hydraulic flow. Keeping the circuit full also insures instantaneous response to the fixed-displacement hydraulic motors.

THE TWO VARIABLE-DISPLACEMENT PUMPS ARE KNOWN AS "A"-ENDS, AND THE TWO FIXED-DISPLACEMENT MOTORS ARE KNOWN AS THE "B"-ENDS. When the two sets of pump motors are connected by tubing, they become known as the BASIC TURRET POWER UNIT. The output volume of each "A"-end is controlled by a servo control valve which is built into the basic power unit. The operation of one "A"-end is identical to the operation of the other "A"-end. This is also true of the two "B"-ends and the two servo valves.

The "A"-end cylinder block assembly is housed in a SWIVEL YOKE held at its axis by two pintles. A VALVE PLATE is mounted on the yoke at its upper end. (See fig. 5–13.) The

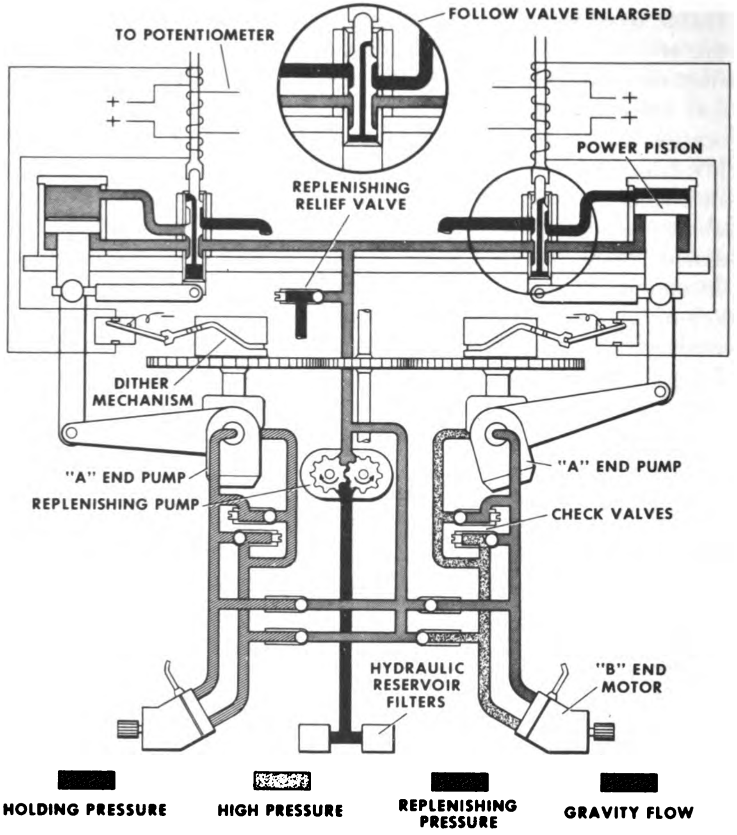


Figure 5–12.—Hydraulic power unit schematic.

yoke may be swung in either direction from the center position on the two pintle shafts which serve as axles. When the yoke moves, the cylinder block and valve plate move with it. Continuous passages are provided in the yoke, valve plate, pintle, and pintle flanges. They allow free passage of fluid to and from the pump through external tubing connected to the pintle flanges. The cylinder block rotates with the pump shaft. It is kept perfectly timed with the pistons through a short link (fig. 5–13) having a universal joint at each end.

When the yoke is in the center or neutral position, there is no pumping action because the cylinder block is rotated in the same plane as the pump shaft. (See fig. 5–13.) Therefore, the pistons have no stroke, and no hydraulic fluid is displaced during the operation of the pump. When the yoke is tilted off center, pumping action takes place. This is because the cylinder block is made to rotate at an angle to the axis of the pump shaft thus producing piston movement. When the yoke is moved to its maximum angle, the greatest pumping action is attained. This is because the pistons are then producing their longest strokes. By moving the yoke, the volume from the pump may be varied in any amount required from zero to maximum capacity depending on the amount of displacement of the yoke.

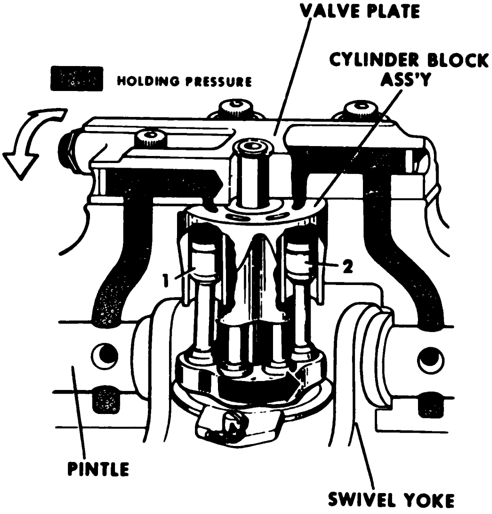


Figure 5–13.—"A"-end hydraulic pump.

Reversal of the fluid flow is attained by moving the yoke to the opposite side of the center position. When the yoke is in the center position, the pistons are rotated in the same plane, and no stroke of the pistons results.

When the unit is positioned where it can be viewed in the direction of the yoke axis, and the yoke is moved to the left (fig. 5–14), the piston (2) assumes the position shown. This creates a low pressure area during one-half revolution of the cylinder block. Each cylinder is filled successively with fluid flowing in from port (4) through the connected passages. The compression stroke now starts as piston (2) assumes the position shown by piston (1) during the other half revolution of the cylinder block. This forces the fluid out through port (3) under high pressure. These successive passages are connected through the swivel yoke, and fluid passes out into external tubing which is connected to the main housing at the pintle shaft flanges.

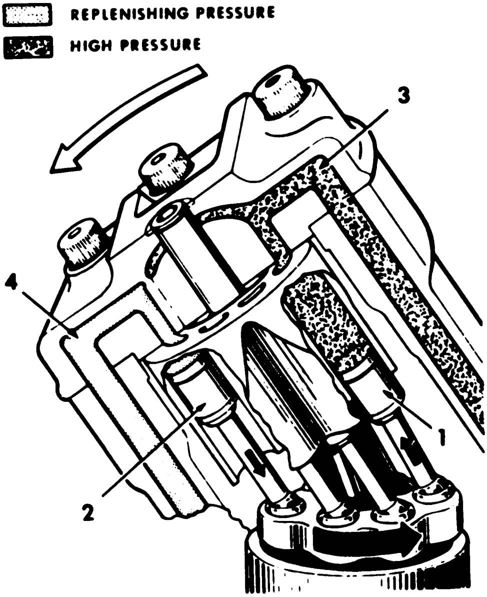


Figure 5–14.—"A"-end pump tilted to the left.

With the yoke tilted to the right as shown in figure 5–15, fluid will then be drawn into port (3) and forced out of port (4). Port (3) which was the pressure port, has now become the inlet port. Likewise, port (4), which was the inlet port, has now become the pressure (outlet) port. It will be noted that when the cylinder block is moved from one side of the center position to the other, the flow of hydraulic fluid is reversed. It will also be noted that the amount of fluid displacement is proportional to the degree of yoke displacement from the center position.

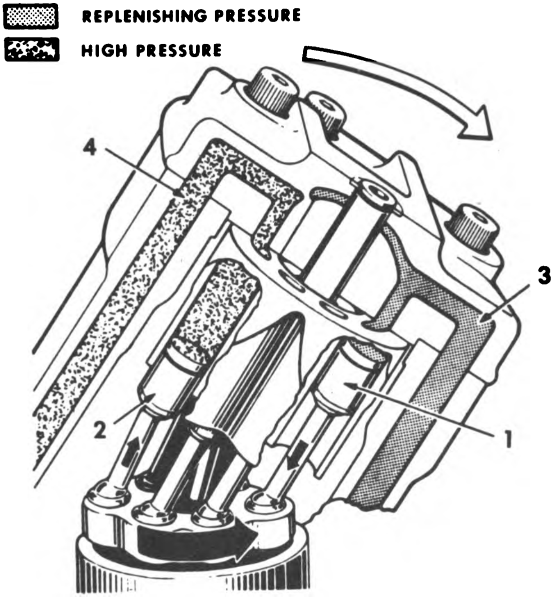


Figure 5–15.—"A"-end pump tilted to the right.

Pressure relief system.—It has previously been explained that the pressure in the line is dependent upon the displacement of the pump and the amount of restriction in the line. Therefore, if the restriction in the line is greatly increased, such as a complete stoppage of the "B"-end motor (this motor is described below), pressure will build up rapidly in the pump until the electric motor stalls or other parts rupture. For this reason it is necessary to provide relief valves to guard against excessive pressures. Two relief valves are necessary since either side of the pump may alternately be a high pressure side. These relief valves are spring-loaded and function automatically when an excess pressure exists on the high pressure side of the hydraulic circuit. This high pressure condition is relieved by the relief valve allowing a small amount of fluid to escape from the pressure side of the circuit to the return side. By relieving pressure in this way, the fluid volume of the pump will be maintained. Thus, the lines will be kept full and the operation of the mechanisms kept smooth without imposing an excessive demand on the replenishing system.

The fixed-displacement motors, or "B"-ends, are driven by fluid from the variable-displacement pumps, or "A"-ends, through connecting tubing. (See fig. 5–11.) The "B"-end drive shaft is set at a fixed angle to the cylinder block. Because of this fixed angle, the "B"-ends require a definite quantity of fluid for each revolution. They are therefore fixed-displacement motors. It will be noted that the drive shaft assembly, on which the lower ends of the connecting rods are attached, must always be kept in time with the cylinder block. This is accomplished by connecting both these units with a stubby universal link (shaft) having a universal joint at each end. (See fig. 5–16.) It is through this link that power is transmitted from the cylinder block to the drive shaft assembly.

When fluid under high pressure from the "A"-end enters the "B"-end through the valve plate at port (3), figure 5–17, it exerts pressure on piston (1). This piston, in turn, pushes against the drive shaft flange through its connecting rod and

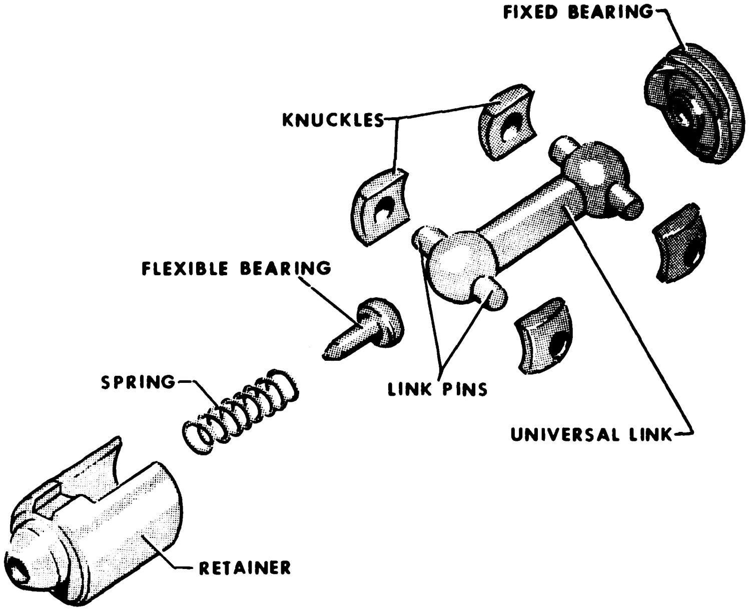


Figure 5–16.—Universal link (shaft) assembly.

ball socket. Since the drive shaft may be rotated freely in its bearings but cannot be forced back against the hydraulic pressure, the piston imparts a rotary motion to the drive shaft. This action takes place during one-half revolution of the "B"-end. During the other half revolution, fluid previously forced into the motor from the "A"-end is expelled to the return line by the pistons which are now moving towards the valve plate. Piston (1) has now traveled around to the position shown by piston (2), and is beginning its return stroke to expel fluid through port (4) to the return line to the pump.

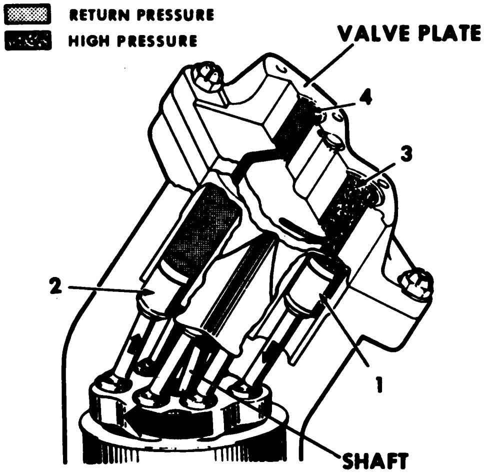


Figure 5–17.—"B"-end motor, clockwise rotation.

As the pistons rotate, fluid pressure acting on one side of the motor is automatically cut off by the ports in the valve plate. These ports are spaced so that they serve as valves to time both the inlet and outlet functions. They also cause pressure to be applied to the pistons in such a way that the desired rotation is accomplished.

If the "A"-end pump is reversed, hydraulic fluid will flow through the "B"-end in an opposite direction as shown in figure 5–18. The high pressure hydraulic fluid now enters port (4). It exerts pressure on piston (2) and forces it down, rotating the drive shaft and cylinder block in the opposite direction as indicated by the arrow. Hydraulic fluid is then expelled through port (3) which becomes a return line to the pump, or "A"-end. This explanation indicates that the direction of rotation of the "B"-end (motor) shaft is automatically reversed whenever the flow of fluid from the "A"-end (pump) is reversed. It also shows that any increase in the hydraulic fluid flow from the "A"-end results in an increase in the speed of the "B"-end motor rotation. Thus, the operation of the "B"-end is directly controlled by the variation of fluid delivered to it from the "A"-end.

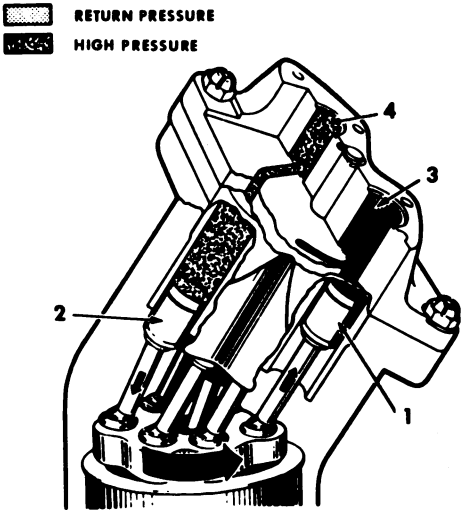


Figure 5–18.—"B"-end motor, counterclockwise rotation.

Fluid replenishing system.—Instantaneous response is mandatory from the components of a turret actuating mechanism. The turret must move quickly and smoothly to the slightest touch of the operator. This requires that the "B"-end motor react quickly and positively to the hydraulic pressure from the "A"-end pump in the Aero 11A turret to accomplish the desired results. This means that the "A"-end pumps, the "B"-end motors, and the connecting fluid lines have to be completely filled with hydraulic fluid at all times. A small gear type **replenishing pump** is connected to the electric motor which furnishes power to the "A"-end pumps. This pump keeps the components of the system replenished with hydraulic fluid. (See fig. 5–12.) The replenishing pump operates at a much smaller maximum pressure than the "A"-end pumps. A large tube is connected to the replenishing pump inlet. Filters are mounted on this same tube. These filters form a "T" with the intake tube, and are placed at the base of the pump reservoir. In this position, they will remain covered with hydraulic fluid at all times.

The replenishing pump has sufficient capacity to keep the hydraulic system filled with fluid under all operating conditions. Surplus fluid delivered by the replenishing pump must be bypassed and returned to the reservoir. An adjustable RELIEF VALVE (fig. 5–12) is placed in the replenishing line to bypass this surplus fluid and to control the operating pressure of the fluid.

Hydraulic fluid is drawn from the reservoir through the FILTERS (fig. 5–12) during the operation of the replenishing pump. The fluid is delivered to the passage of the main housing. These passages connect with the lines between the "A"-ends and the "B"-ends at the pintle flanges. These pintle flanges are integral parts of the pintles supporting the "A"-end yoke to which the lines between the "A"- and "B"-ends are connected.

Spring-loaded CHECK VALVES are installed in the pintle flanges. They insure that the replenishing action of the circuit occurs only in return lines between the "A"- and "B"-ends. It will be remembered that either of the two feed lines may alternately be the return line due to the reversing action of the "A"- and "B"-ends. The pressure maintained in the passages by the replenishing pump is sufficient to open the check valve in the return line side of the "A"-end, thus replenishing it. The check valve in the pintle flange on the pressure side of the "A"-end is held closed by the high pressure in the line between the "A"- and "B"-ends. Therefore, replenishing fluid cannot enter at either side, nor can the high pressure from the "A"-end enter the replenishing circuit. When the flow between the "A"- and "B"-ends is reversed, the replenishing action is also reversed.

SERVO CONTROL SYSTEM.—As previously shown, the amount of hydraulic fluid moved by the "A"-end pumps is determined by the amount of displacement of the pumps from their center (neutral) position. There will naturally be a large force tending to oppose any shift in the displacement of the "A"-end pumps while they are operating. This is due to the pressure within the pumps trying to right the pumps to their neutral position in which no fluid is circulated. This force originates when the servo control assembly is energized and displaces the follow valve through the mechanical linkages. Movement of the follow valve causes hydraulic pressure to move the power piston up or down. Movement of the power piston causes the pump to tilt. The pumps are maintained at any desired displacement from neutral by the continuing force of the servo controls acting through the mechanical linkages.

Each servo control valve assembly consists of a **POWER PISTON**, a **FOLLOW VALVE**, and a **SLEEVE** in which the follow valve operates. (See fig. 5–12.) This assembly is mounted on the top cover of the unit in a suitable housing. The power piston is connected by linkage to the "A"-end yoke, and to the follow valve sleeve. The follow valve sleeve is indirectly connected to the control handle in the turret through an electrically operated solenoid. This solenoid moves the follow valve which, in turn, causes the power piston to be moved proportionately. This movement causes rotation of the "A"-end pump from its neutral position. Each solenoid is energized by an electric current from the amplifier unit. The strength of this current is controlled by a potentiometer in the control handle assembly.

The power piston is operated by hydraulic pressure supplied by the replenishing pump through passages in the main housing, by way of the fluid ports in the swivel yoke. (See fig. 5–19.) The main housing is connected to the servo housing by additional passages. Control of this fluid is accomplished by the follow valve. When the follow valve is held at its center position, fluid pressure from the replenishing pump to the underside of the power piston cannot force the power piston to move upward because there is no escape for the hydraulic fluid trapped above the piston. The power piston therefore is kept in the center position by the balance of the hydraulic force, both above and below the piston.

When the power piston is held in the center (neutral) position, it will hold the "A"-end yoke in the center position because of the mechanical linkage between them.. When the follow valve is moved upward, it will open the ports allowing additional fluid to flow to the top of the power piston.

The area of the top of the piston is TWICE AS GREAT as the area on the bottom of the piston. This is due to the large diameter connecting rod being attached to the bottom of the piston. Since there is twice the area on TOP of the piston as there is on the bottom, there will be twice the force exerted on the top of the piston. Therefore, when the same amount of fluid pressure acts on both the top and bottom of the piston at the same time, the piston will be forced downward. As the power piston moves downward, the follow valve sleeve which is linked to it will move upward. This closes off the ports through which fluid flows to the top of the power piston.

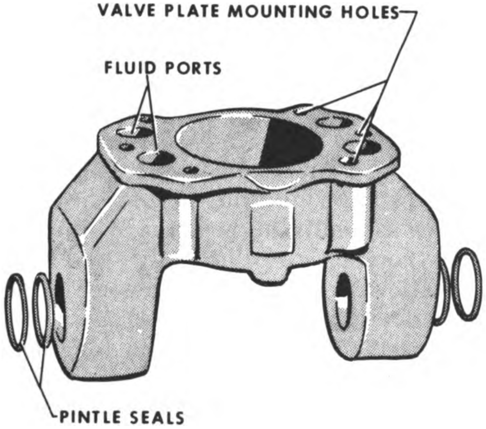


Figure 5–19.—The swivel yoke.

It will be seen that the travel of the power piston is limited to an amount proportionate to the travel of the follow valve. Therefore, the amount of tilt to the "A"-end yoke is determined by the position of the follow valve. Because of this the "A"-end only moves far enough to supply the amount of pumping action required, as determined by the position of the control handles.

When the follow valve is moved downward, the power piston is moved upward, reversing the action described above. It is noted that all movements of the follow valve are translated into movement of the "A"-end yoke. The yoke may be displaced to either side of its neutral position (from zero to maximum displacement) by an extremely light pull of the control solenoid on the follow valve.

DITHER MECHANISM.—A law of physics shows that when a piece of metal rests on or against another piece, a considerable amount of energy is required to place either of these pieces in motion. It further shows that when either of these two pieces is in motion, it requires less energy to maintain it in motion than was initially needed to start the motion of the piece. The tendency of these two pieces to cling together is known as STATIC FRICTION. If a method were not provided to overcome this static friction in the follow valve and its associated parts, sensitive response to control movements would be impossible. Therefore, it would be extremely difficult to track a moving target smoothly and accurately.

To overcome static friction, a DITHER MECHANISM (figs. 5–12 and 5–20) has been incorporated with the servo control assembly to set up a series of minute oscillations, or vibrations, on the follow valve. The practical value of maintaining these constant vibrations is that the components of the follow valve assembly never actually stop moving (vibrating) even though the follow valve and sleeve are not operating. Static friction in the assembly is therefore reduced to practically zero.

There is a separate dither mechanism for each servo control valve assembly. Each mechanism consists of a cam-operated, single-pole, double-throw, vacuum-type switch, and an extra pair of coils in the solenoid which operate the follow valve. These vacuum switches are being replaced on later turrets by electronic tubes. The cam arm is actuated by the rotation of the "A"-end drive shaft. It is mechanically linked to the switch arm in such a manner that rotation of the "A"-end shaft results in a very rapid and alternate making and breaking of the switch contacts. As a result, a PULSATING DIRECT CURRENT is set up in the extra pair of solenoid coils which are in the circuit with this switch. The solenoid armature is caused to oscillate with a minute and rapid motion. This motion is transferred to the follow valve with which the solenoid is connected. This transfer constitutes the desired dither effect.

The pulsating direct-current magnetic flux (magnetic force) set up in the solenoid by the operation of the dither

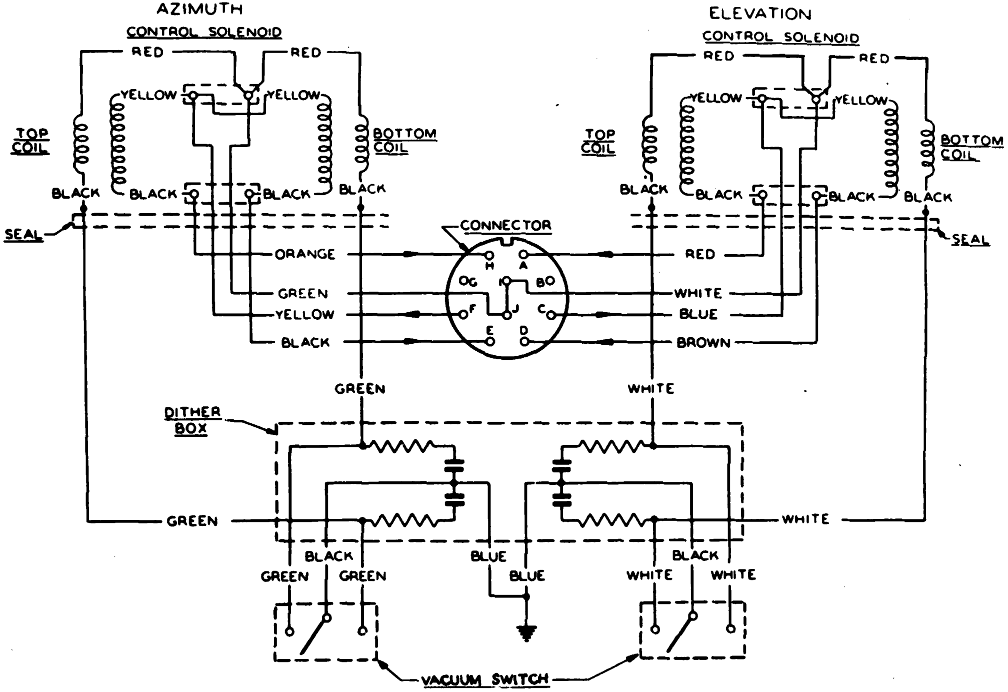


Figure 5–20.—Power unit electrical schematic.

circuit is superimposed on the greater flux which operates the solenoid itself. Superimposing this added flux does not hinder the movement or normal operation of the solenoid. The dither mechanism flux operates continuously regardless of whether the solenoid is in operation or idle.

The dither system for the Aero 11A–2 turret has a modified circuit in that it employs THYRATRON TUBES to produce the oscillations rather than a cam and make-and-break switches. The end results of both systems are similar.

FLUID FLOW TO THE SYSTEM.—For purposes of clarity it is well to think of the pumping systems as two separate circuits. (See fig. 5–12.) One of these circuits will be the low pressure circuit, and the other the high pressure circuit. The LOW PRESSURE CIRCUIT operates the power piston, and replenishes the high pressure circuit in the following manner. Fluid is drawn from the sump, or reservoir, by the replenishing pump and delivered at control pressure to the servo control valve assembly. From here the fluid is routed to the replenishing check valves in the pintle flanges. Control of the fluid in the servo control valve assembly is achieved by the follow valve which determines movement of the power piston. The control of the fluid delivered to the replenishing check valves is automatic. Replenishing of the high pressure circuit as needed is accomplished only on its return side.

The high pressure circuit operates between the "A"- and "B"-ends of the system. It may be considered a closed circuit, since the fluid contained in it is constantly circulated between these two points. The initial filling of the high pressure circuit is accomplished by the low pressure circuit through the replenishing check valves in the pintle flanges. Once the high pressure circuit has been filled, it is kept filled by the low pressure circuit. This replenishing is accomplished automatically by the check valve at the return side of the high pressure circuit.

SUMMARY OF HYDRAULIC OPERATIONS.—Displacement of the turret control handles moves the follow valve in the servo control valve assembly by means of the solenoid. This action is transmitted and amplified hydraulically by fluid supplied by the replenishing pump. This causes the power piston to move proportionately. Since the power piston is linked to the "A"-end swivel yoke, it moves with the power piston, creating pumping action. Fluid pumped by the "A"-end is transmitted through tubing to the "B"-end, causing it to rotate. This fluid from the "B"-end is returned to the "A"-end making a continuous circuit. The normal hydraulic "slip" in the operating parts is compensated for by the replenishing pump. This pump replenishes the circuit between the "A"- and "B"-ends. Relief valves are placed in the circuit to protect the unit against overloads. Another relief valve is incorporated in the replenishing circuit to limit the pressure in that circuit. This valve is spring-loaded and is adjustable from the outside of the hydraulic power unit.

When the control handle of the turret is moved, either in azimuth or elevation, the "B"-end motor responds immediately by rotating at a speed proportional to the displacement of the control handle and in the direction determined by the control handle position. Therefore, the turret movements are always in response to the control handle movements. This affords the gunner complete and accurate control of the turret at all times.

ELECTRICAL SYSTEM.—Electrical energy is supplied to the turret by the 28-volt, d-c aircraft electrical system. (See fig. 5–21.) Various units which operate directly from the electrical system are: suit heater, cockpit lamp, boresight switch (when in BORESIGHT position), master switch, and the two boosters when the switches are in the LOADING position. The suit heater has a standard outlet connection protected from the main power supply by a thermal breaker. The cockpit lamp incorporates a separate switch built into the cockpit lamp unit. The lamp circuit is also protected by a standard thermal circuit breaker. The master switch has one positive pole connected directly to the aircraft power supply circuit, so that when the circuit is closed the power relay coil is energized. This action closes the power relay contacts and energizes the greater part of the electrical system. The boresight switch is a two-way switch, and when in the BORESIGHT position, the Mk 18 gunsight lamps are ON. This arrangement makes it possible to harmonize the sight without turning on any other units of the electrical system.

When the master switch is ON, the power relay is closed and current is supplied to the following units: amplifier,

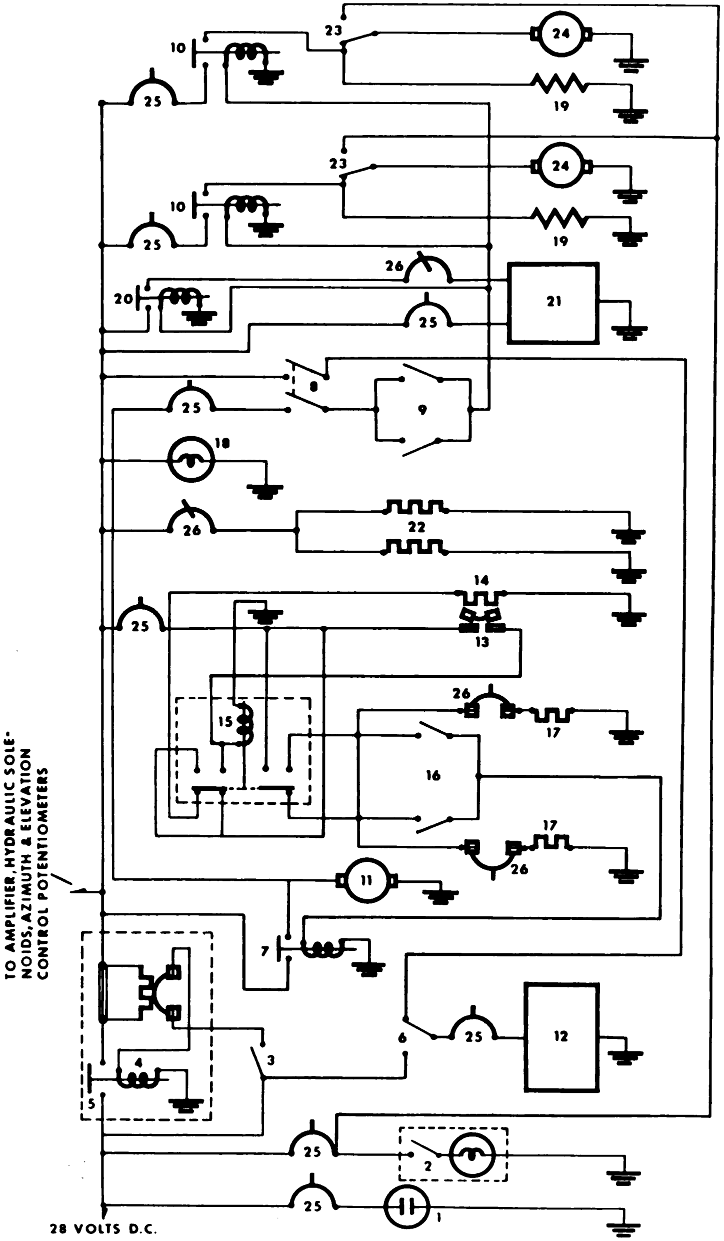

TO AMPLIFIER, HYDRAULIC SOLENOIDS, AZIMUTH & ELEVATION CONTROL POTENTIOMETERS
28 VOLTS D.C.
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Figure 5–21.—Wiring diagram schematic.

Key to figure 5–21

1. **Suit heater outlet**
2. **Trouble light**
3. **Master switch**
4. **Power relay coil**
5. **Power relay contacts**
6. **Boresight switch**
7. **Action relay**
8. **Fire-safe switch**
9. **Trigger switches**
10. **Gunfiring relay**
11. **Hydraulic power motor**
12. **Mk 18 sight**
13. **Time delay relay**
14. **Time delay heater**
15. **Auxiliary relay**
16. **Action switches**
17. **Potentiometer heaters**
18. **Indicator light**
19. **Gunfiring solenoids**
20. **Camera relay**
21. **Gun camera**
22. **Gun heater**
23. **Booster loading switches**
24. **Booster**
25. **Thermal circuit breakers**
26. **Thermal switches**

action relay, one pole of the fire-safe gun switch, three poles of the auxiliary relay, gun heaters, the time delay relay heater, indicator light (shows when power relay contacts are closed), gun camera relay, heater coil in the camera, and the gunfiring relay contacts. When the time delay relay closes the auxiliary relay contacts, power is supplied to the action switches. Closing the action switch energizes the action relay. This energizes the hydraulic power unit motor and supplies power to the second pole of the fire-safe switch. When the fire-safe switch closes, power is supplied to the trigger switches and the gunsight. Closing the triggers energizes the gunfiring and camera relays. The time delay relay prevents operation of the hydraulic power unit before the amplifier is warmed up enough to become operative. If it were not for this relay, the turret would operate immediately after closing the master and action switches.

It takes about 30 seconds for the amplifier to warm up sufficiently to allow it to operate properly. If the turret were operated during this time, it would overrun its limits and cause considerable damage to both turret and fuselage. The time delay system functions as follows: When the master switch is closed, current from the aircraft's supply energizes the power relay coils and closes the power relay contacts. This action energizes the time delay heater through one set of normally closed contacts of the auxiliary relay. The heater is adjacent to the thermostatic switch contacts. It causes these contacts to close, energizing the auxiliary relay coil. When the auxiliary relay coil is energized, it opens the pair of normally closed contacts, and closes the pair of normally open contacts. The coil of the relay is energized by its own contacts, and will hold the contacts in this position until released by the opening of the master switch. The trigger switch is not effective until the action relay is energized.

Caution: Be sure that the control handle is in the NEUTRAL POSITION before operating the power motor (hydraulic) if the amplifier is cold or disconnected. Failure to comply with this precaution will allow the turret to overrun the antiference control limiting mechanism. This will cause severe damage to the turret.

The ELECTRICAL SYSTEM OF THE AERO 11A–1 AND 11A–2 TURRETS differs from the system of the Aero 11A turret. In addition, the Aero 11A–1 turret has gun charger and gun control circuits. These circuits are energized by a 115-volt, 400-cycle alternating current from the 400-cycle supply of the aircraft. This voltage is stepped up and then rectified to between 200- and 300-volts direct current. The Aero 11A and 11B turrets make use of the gunfiring solenoids.

The AMPLIFIER ASSEMBLY is provided to take the voltage signals from the azimuth and elevation control potentiometers and convert them to the proper current values for operating the control solenoids. These solenoids are located in the hydraulic power unit. Current at the control solenoids, in the hydraulic power unit, is determined by the position of their respective control potentiometers. The potentiometers are wound with extremely fine wire to provide smooth, sensitive response to the control handle movements.

Warning: Never operate the trigger switch for the purpose of checking gun camera or booster operation when the guns are loaded.

NOTE: There are two switches on the switch panel for the left- and right-hand ammunition boosters. These switches may be used to help load ammunition without danger of firing the guns.

PRECAUTIONS.—Before the Aero 11A turret is operated, either by the gunner or servicing operator, certain precautions MUST be observed. These precautions are necessary in order to avoid damage to equipment and to eliminate any possibility of injury to personnel. The following precautions should be studied until they become a habitual part of the operating routine:

1. Never occupy the turret during takeoff or landing. To do so places the occupant in a dangerous position in case of mishap. The extra weight of an operator in the tail position alters the flight characteristics of the aircraft during takeoff and landing.
2. Whenever climbing into or out of the turret during flight, be sure to hold on to the structural member of the aircraft to prevent being bounced around by rough air. Carelessness in this matter may cause bodily injury.

Warning: Never try to swing into the gunner's seat with both feet at one time. Always use proper entrance methods as shown in applicable instructions.

3. Make sure that the turret master switch is in the OFF position when entering or leaving the turret. With this switch in the ON position, there is great danger of accidentally striking the action switch on the control handles. Should this happen, the turret ball will move if the control handles are not exactly in the neutral position. Such a condition would be extremely dangerous for anyone entering or leaving the turret.
4. Keep the fire-safe switch in the OFF position until ready to fire the guns.

NOTE: The operator should invariably check the switch panel to insure that all secondary switches are off before closing the master switch. This permits the operator to energize each unit as he needs it after closing the master switch.

5. When leaving the turret, stow the guns in their proper positions. This stowed position is zero azimuth and zero elevation, which is read from the azimuth and elevation indicator scales.
6. Turn OFF the sight motor during takeoffs and landings. Always check the turret switch panel after climbing out of the turret and turn to OFF all switches not so positioned. This should be the last check made before leaving the tail area of the fuselage.
7. Read all instructions printed on decals and other warnings posted in the vicinity of the turret thoroughly enough to become familiar with their messages. These reminders are placed in full view for the safety of personnel and the protection of the equipment.

Caution: Do not use the control handles or sight brackets for handholds when entering or leaving the turret. Also avoid swinging into the gunner's seat with the right foot on the range control pedal.

8. To enter the turret properly,
   a. adjust the gunner's seat to your height,
   b. place the left foot on the footrest securely,
   c. take firm hold of the two upright tubular assist handles,
   d. raise the right foot over all obstructions,
   e. slide carefully into the seat, and
   f. settle into a comfortable position and place the right foot on the range control pedal.
9. Connect the microphone and headset plugs and establish contact with other crew members.
10. Check all switches for proper positioning, and the mechanical ranging mechanism of the sight for operation.
11. Connect the suit heater cable to the plug-in on the right-hand side near the turret junction box.

POWER OPERATION.—Check the position of the azimuth and elevation handcranks. Each handcrank should be rotated out of contact with the square end of its control shaft, and held in a disengaged position with the restrainer strap attached to the shell of the tail assembly. Move the master switch lever to the ON position and let the amplifier warm up for at least 30 seconds.

NOTE: The master switch MUST be turned ON for at least 30 seconds before the hydraulic power unit will operate due to the time delay feature of the electrical system.

Grasp the control handles and position the control unit approximately in the neutral position. Depress one or both of the action switches. This will cause the power unit to operate, and make the turret responsive to the control movements. Operate the turret slowly in azimuth and elevation to test its responsiveness.

Caution: If, for some reason, the circuit breaker in the amplifier unit should open when the turret is being operated, the controller and limit stop switches will cease to function. However, the turret movement will occur, or continue to occur. If this should happen, turn OFF the turret power immediately.

CHARGING THE GUNS.—Charge the guns before entering the combat zone if practicable. The guns of the Aero 11A turret are charged manually. To manually charge the guns, grasp one charging handle and brace yourself. A strong pull is necessary to complete the charging cycle. Pull the charging lever all the way back sharply and release it. Charge the other gun the same way.

Warning: Before leaving the turret, the guns must be placed in a stowed position; trained horizontally aft and not drooping. Failure to do this may result in damage to both aircraft and turret during takeoffs and landings. It is possible for the guns to strike the runway in certain installations if not properly stowed.

Maintenance

The most effective method of insuring proper operation of the aircraft turret is to set up a system of daily or preflight inspections, and see that they are carried out. These inspections will necessarily differ with the type of armament and aircraft involved. Correction of the discrepancies found in the daily inspections will materially reduce the number of serious breakdowns of the equipment.

A series of daily inspections for the Aero 11A guns might be as follows:

1. Check the manual operation of all switches on the switch panel of the junction box.
2. Inspect both right- and left-hand ammunition chutes for dents, sharp bends, and rough spots which would impede free movement of the ammunition belts. See that the ammunition chutes are positioned where they will not interfere with other components, both inside and outside the turret ball.
3. Check the ammunition boxes for fit in their mounting channels. Also see that the ammunition box lids and holddown provisions are correct.
4. Inspect guard rails for protection of the gunner's legs and ammunition chutes. Make sure that they have not been bent out of normal shape.
5. Check level of the hydraulic fluid in the hydraulic power unit. Fluid level should be even with the white line near the top of the sight gage. (See fig. 5–3.)
6. Make a careful inspection of all hydraulic lines for indications of leaks. Also check tubing for dents, short bends, and other damage.

7. Check the hydraulic power unit for indications of leaks around the gaskets and tube fittings.
8. Check the gunner's seat for security of mounting and height adjustment.
9. Test the operation of the azimuth and elevation handcranks. Do NOT operate the turret by hand past the normal operating ranges. To do so will damage the turret and aircraft fairing, as there are no mechanical stops in either the azimuth or elevation movements.
10. Inspect all wiring for chafed, torn, or damaged insulation. See that cables are retained in their proper locations.
11. In the Aero 11A, 11B, 11A–1, and 11A–2 turrets, check operation of the hand gun chargers by performing at least one charging cycle on each gun with the guns pointed in a safe direction.
12. Inspect the guns for cleanliness, evidence of proper lubrication, and adjustment. Also, check both front and rear gun mounts, insuring that all bolts are tight and that the front gun mount release pawls are fully engaged.

Warning: From this point forward in the inspection, do not perform any of the following tests with the guns loaded.

13. Check the ammunition feed mechanism on guns and boosters located on the ammunition boxes. Also, check the ammunition chutes to insure that they are properly connected to the booster and feeders. See that the feeders are securely latched in place on the guns.
14. Check for torn or damaged weather seals around the turret ball.
15. Check the transparent plastic canopy for cleanliness, scratches, cracks, and crazing.
16. Check the oil level in the oil reservoir located at the base of the compressor after each flight. Drain the pressure tank by removing the drain plug at the base of the tank.
17. Make a visual inspection of the sight control unit by checking the mechanical operation of all control knobs. Also, check condition of all electric gunsight cables, making sure that the flexible metal shields are intact and attached securely to their connectors at both ends of each cable.

18. Check the operation of the range control. The return spring should return the pedal automatically to its upper position each time it is released.
19. Open the latch door on the sighting head and turn ON the boresight switch. This should illuminate both sight lamps. Rotate the dimmer knob on the control unit to determine if the brilliance of both lamps varies evenly with respect to rotation of the dimmer knob.
20. Check sight lenses and filter glass for cleanliness.
21. Check mechanical condition of the action and microphone switches. Movement of the operating levers should be accompanied by a sharp, low click, and the levers should return to their normal OFF position immediately when released.
22. Check the intercommunication system by talking to another operator in the pilot's compartment, then with other stations within the aircraft.
23. Turn ON the master switch, fire-safe switch, and camera switch. Check the operation of the camera motor when either gun camera toggle switch is depressed.
24. Plug in heated suit, or check the heated suit receptacle with a 24-volt d-c test lamp.
25. Operate the turret in all movements to check the turret response to the control movements.

QUIZ

1. When the action switches on the Aero 11A turret are depressed, they actuate the
   a. gun chargers
   b. Vickers power unit
   c. booster motors
   d. drive motors

2. The guns on the Aero 11A–2 turret are charged
   a. manually
   b. electrohydraulically
   c. hydraulically
   d. electrically

3. The purpose of the dither mechanism on the Aero 11A turret is to
   a. Prevent static friction between follow valve and follow valve sleeve
   b. prevent pump from building up excessive pressure
   c. aid the follow valves in their downward movement
   d. prevent the control solenoids from burning up

4. The amplifier on the Aero 11A turret receives voltage from the
   a. control solenoids
   b. dither mechanism
   c. potentiometers
   d. time delay relay

5. The purpose of the time delay relay on the Aero 11A turret is to
   a. prevent an overload on the junction box
   b. allow sufficient time for the power unit to warm up
   c. prevent control solenoids from burning up
   d. allow sufficient time for amplifier to warm up

6. The power pistons in the Vickers hydraulic power unit on the Aero 11A turret changes the position of the
   a. follow valves
   b. Vickers pumps
   c. control solenoid core
   d. dither mechanism

7. During power operation the Aero 11A turret is prevented from driving beyond normal operating limits by the
   a. structural interrupter
   b. antiference mechanism
   c. length of piston travel
   d. exterior ball stops

8. The hydraulic drive motors on the Aero 11A turret are
    a. constant speed and constant displacement
    b. constant speed and variable displacement
    c. variable displacement and variable speed
    d. constant displacement and variable speed

9. The special long-handled wrench is used to
    a. manually operate the turret from the outside
    b. return the turret to neutral in case it overrides its limits
    c. wind the ammunition feed mechanism spring
    d. tighten the booster motors torque spring

10. Of the following switches located in the Aero 11A turret, which one can be energized without having the main power switch ON?
    a. Safe-fire switch
    b. Action switch
    c. Trigger switch
    d. Boresight switch

11. The Vickers hydraulic power unit on the Aero 11A turret contains
    a. two pumps
    b. two motors
    c. three pumps
    d. three motors

12. The replenishing pressure on the Aero 11A turret is used to operate the
    a. follow valve
    b. gear pump
    c. power piston
    d. hydraulic motor

13. A pertinent equipment safety precaution is to
    a. keep feet inside guard rail
    b. stow guns horizontally aft and not drooping
    c. keep the fire-safe switch OFF
    d. make sure the manual handcranks are engaged

14. The power clutch is engaged by
    a. a selector handle
    b. stowing the manual drive handles
    c. engaging the manual drive handles
    d. a selector switch

15. The old dither mechanism consists of
    a. alternate firing vacuum tubes
    b. a set of coils, wound in series
    c. a pump and vibrator in power unit
    d. a single-pole, double-throw vacuum switch

16. Which of the following are located in the Vickers hydraulic power unit?
    a. Control potentiometers, follow valves, and check valves
    b. Dither mechanisms, power pistons, and control solenoids
    c. Potentiometer heaters, check valves, and follow pistons
    d. Five relief valves, four check valves, and damper units

17. The prime mover of the hydraulic power unit is rated at what horsepower?
    a. 2
    b. 2¼
    c. 4
    d. 5

18. When the master switch is closed, which of the following sets of relays must function before the electric drive motor will energize?
    a. Time delay, action, main power, and solenoid
    b. Main power, time delay, and action
    c. Main power, action, booster motors, and auxiliary
    d. Main power, time delay, auxiliary, and action

19. The follow valve controls the replenishing pressure to the
    a. "B"-ends
    b. "A"-ends
    c. power piston
    d. potentiometers

20. The purpose of the central ring assembly is to
    a. mount the guns and allow them to turn to azimuth
    b. hold the elevation segment gears in place
    c. act as a track for the plastic ball bearings
    d. hold the bell assemblies together and allow them to rotate

21. The Vickers hydraulic pumps are
    a. variable speed, variable displacement, one direction of tilt
    b. variable speed, constant displacement, two directions of tilt
    c. constant speed, variable displacement, two directions of tilt
    d. constant speed, constant displacement, one direction of tilt

22. The gunner should enter the turret with the left foot first to prevent
    a. accidental displacement of the control handles
    b. putting his weight on the sight range pedal
    c. putting his weight on the feed chutes
    d. stepping on the power unit

23. A preflight inspection of the Aero 11A turret consists primarily of
    a. checking all lubrication points
    b. checking all switches to be sure that they are in the OFF position
    c. checking the turret to see that it operates properly
    d. checking turret to be sure it is properly stowed

24. The Aero 11A turret is controlled electrically and operated
    a. hydraulically
    b. electrically
    c. mechanically
    d. pneumatically

CHAPTER 6

ILLUMINATED AND COMPUTING GUNSIGHTS

ILLUMINATED GUNSIGHTS

Gunsights Mk 8 and Mk 20 and Mods

The Illuminated Gunsights Mk 8 and Mods and Mk 20 and Mods (figs. 6–1 and 6–2) will be discussed together because they are similar in construction and use. For more detailed information on each sight and its modifications refer to proper Ordnance Pamphlets.

DESCRIPTION.—The Mk 8 and Mk 20 illuminated gunsights are collimating reflector type sights. The rays of light produced by the lamp (see figs. 6–1 and 6–2) are made parallel to each other in these sights. The rays pass through the reticle which is at the focal plane of the sight, and are collimated, or made parallel to each other, in passing through the lens system. Both sights contain an illuminated fixed or selectable reticle image pattern. However, the Mk 8 reticle is selectable only in the sense that it is possible to take the sight apart and change the reticle. The sights discussed here are aiming devices installed in a fixed, forward firing position. Leads are estimated by placing the center of the reticle pattern ahead of the relative target motion in accordance with established information and practice. These sights are used as a primary gunsight in aircraft equipped with bombs, fixed forward firing guns, and rockets.

The sights are boresighted to place the ZERO SIGHT LINE parallel to the BORESIGHT DATUM LINE. The sight, by projection of a reticle pattern over the target as seen through the reflector plate or windshield, provides a reference for estimating and introducing leads in gunnery and rocket firing.

The Mk 8 and the Mk 20 and Mods are used according to the particular type aircraft involved. The Mk 20 Mod 0 was especially designed as a night fighter sight. Usually

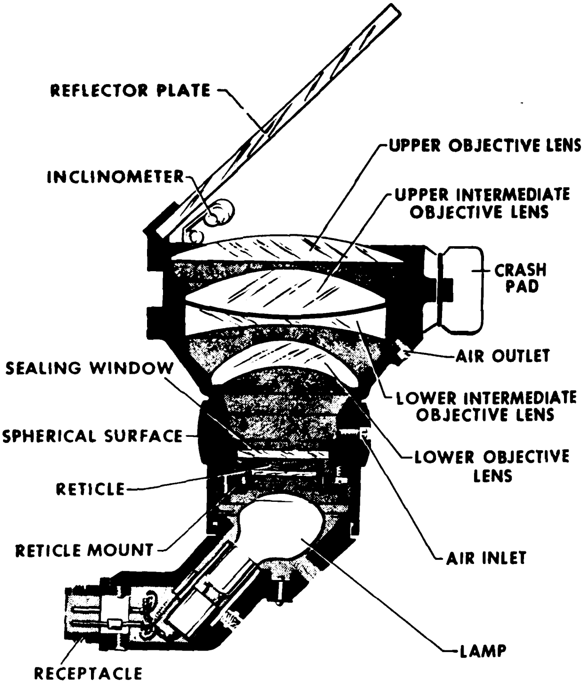


Figure 6–1.—The Mk 8 Mod 8 gunsight.

the bullet resistant windshields are used as a reflector plate for the reticle image projection instead of the reflector assembly. Where it is not possible to use the windshield as a reflector plate, the regular reflector plate assembly is installed on the sight. The assembly fits on top of the upper part of the sight casting.

Installation.—The installation of the Mk 8 and Mk 20 sights in aircraft is accomplished by a mounting bracket with four bolts. There are several modifications of the mount which accommodate the various modifications of the sight. The mount is fastened to the instrument panel so that the distance of the eye from the collimating lens is as short as practicable to minimize the head movement required. This means that the reticle pattern is reflected in the proper position for use by the pilot. In cases where the reflector plate is used, the sight is mounted so that it is easily accessible to the pilot, but does not block his view when landing or during other operations when the sight is not in use.

The electrical wiring enters the sight through the lamp housing which is made of plastic. The single-element lamp is easily installed as it requires only a voltage supply and a ground wire. The two-element lamp requires two voltage supply wires, and a single ground wire. Two filaments are incorporated in the lamp so that if one burns out the other is energized by a switch in the sight circuit.

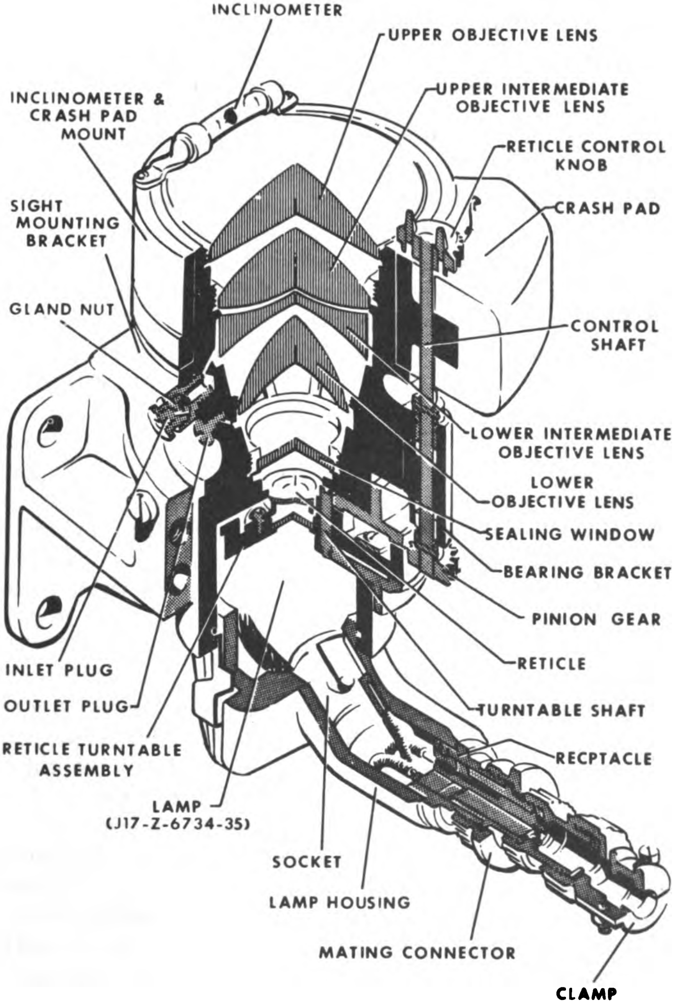


Figure 6–2.—The Mk 20 Mod 0 gunsight.

Each sight has, separate from the sight, a rheostat to vary the brightness of the image and an ON–OFF switch for the lamp. For the two-element lamp the switch must be single-pole double-throw.

MAINTENANCE.—Check the security of the mount to aircraft and the sight to mount. The windshield or reflector plate and objective lens are cleaned with lens tissue. Examine the lamp and if it shows signs of blackening, it should be replaced. Energize the lamp circuit and note that a reticle image pattern is visible on the reflector plate or windshield, whichever is in use. Operate the filament selector switch to make sure both filaments are good. Adjust the dimmer rheostat through its full range and observe the variation to insure that the rise and fall of intensity is even.

When possible, align the sight on a target about 500 feet distant. The reticle image should appear clearly defined and without parallax. To inspect for parallax, move the eye from side to side over the width of the image. There should be very little apparent shift of the reticle image with respect to the target as the head is moved. If the image shifts more than one mil per inch of head displacement (face ten inches from center of reflector) in any direction, the optical system is out of collimation, or focus, and the sight should be replaced.

BORESIGHTING.—Boresighting the Mk 8 and Mk 20 and Mods illuminated sights consists of aligning the line of sight so that it is parallel to the boresight datum line of the aircraft. A wide variance will be noted in the sight mounts. Most sight mount types differ from one another in that each will have its own peculiarity in arrangement and adjustments for azimuth and elevation.

When boresighting the sight, check the Maintenance Instructions for the plane in which the particular sight is used. In this manual will be found a diagram of a boresight templet, as well as all the figures necessary for aligning the aircraft, guns, and camera at a predetermined distance. Variations can be worked out on any portion of the templet for a different fire pattern or for other variations of attack tactics. Check the sight to make sure it is correctly mounted, all mounting bolts tight and safety-wired, and the adjustments secured. Make azimuth adjustments first because this action does not move the pip straight but in a curved path as it is adjusted. Then set the elevation and insure that the locks are drawn up tight. Details are not given here because there are too many different types of mounts which accomodate the various modifications of the sight.

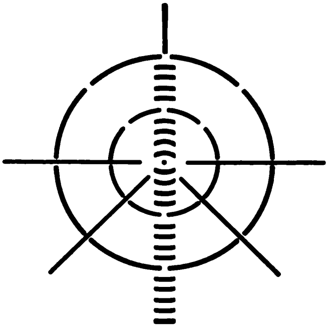
To discuss the sights together it must be realized that requirements are different in each type of aircraft. When a sight cannot be located properly with respect to the windshield so that the reticle image will be properly aligned for use of the pilot, an adapter (reflector assembly) has to be used. There are two kinds of reflector assemblies: the FIXED and the ADJUSTABLE. The fixed is, of course, stationary and is used mostly for gunnery. The adjustable is used for estimating leads in dropping various stores. A foam rubber crash pad and an inclinometer are mounted on the reflector assembly (when the reflector assembly is not used with the sight these items are mounted on an adapter). The inclinometer is used by the pilot as a quick reference to determine whether or not the plane is in a skid during a firing run or dive.

There are different mounts to take care of the various modifications of the Mk 8 and Mk 20 sights. To illustrate this, the Mk 20 Mod 0 has a reticle turntable bracket assembly. This makes it possible to position for use one of three reticles, each with its own light filter. The mount must be adapted for this sight modification. This assembly makes the sight more adaptable to different types of missions.

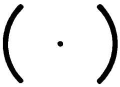
The day reticle (using a yellow filter) of the Mk 8 sight consists of 50- and 100-mil rings, with 90-, 135-, 225-, and 270-degree radial lines drawn to the vertical, and a vertical ladder of 10-mil increments. The 10-mil increments and radial lines are used as reference lines in gunnery. (See fig. 6–3.) The night fighter reticle (using an orange filter) consists of a central dot, or pip, and two 90-degree arcs on the 50-mil ring.

The combination night and day reticle (using an opal filter) consists of a dot, or pip, two 90-degree arcs on the 50-mil ring, the lower half of the 100-mil ring, and three radial lines beginning at the 50-mil ring and ending at the 150-mil position (one at 135 degrees, one at 180 degrees, and one at 225 degrees to the vertical).

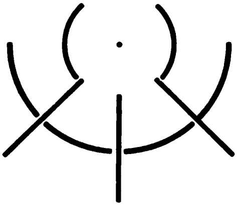
Internal fogging of the sights can be controlled by the use of dry nitrogen under pressure. The interior of the sight is sealed during assembly. However, this procedure does not assure a permanent seal, and provisions are made for dehydration and recharging within the squadron. The sight body is equipped with an inlet valve and an outlet plug, shown in figure 6–2. To remove the moisture, raise the pressure of dry nitrogen in the sight head to 5 pounds and then exhaust. Continue this process at least twice after all traces of moisture have disappeared and reseal optics under three pounds of pressure where possible.



DAY RETICLE
(YELLOW FILTER)



NIGHT FIGHTER RETICLE
(ORANGE FILTER)



COMBINATION
DAY & NIGHT RETICLE
(OPAL FILTER)

Figure 6–3.—The three reticles.

When retightening the gland nut under the inlet plug, it is very easy to overtighten this seal. Do not tighten the gland nut excessively as its associated steel ball will injure the valve seat.

Most alignment troubles come from personnel entering or leaving the cockpit and using the crash pad of the sight for a handhold. Misalignment and damage are certain to result. This can be prevented by constant vigilance and informational instructions to those who enter the cockpit.

Gunsight Mk 20 Mod 4

The Illuminated Gunsight Mk 20 Mod 4 is a development of the Illuminated Gunsight Mk 20 Mod 0. The modifications to the Mod 4 consist mainly of a manually adjustable reflector plate. This reflector has been added to make it possible to offset the line of sight from the boresight datum line. Minor modifications include the substituting of an additional elevation boresight screw and two lock bushings for the mounting spring on the Mod 0. This screw and bushing are substituted to reduce vibration of the sight body in the mounting bracket during flight.

The knob assembly and gear housing for adjusting the reflector plate are located on the left side of the sight body. The adjustable reflector plate is mounted on the sight so that its angle of inclination may be varied within the limits of 75 mils upward and 350 mils downward. You will recall that a mil is the angle generated when the radius is 1,000 times the arc. The purpose of the adjustable reflector plate is to offset the line of sight required for the release of different kinds of armament.

During a single mission, the line of sight may be changed rapidly and accurately to the offset required for fixed gunfiring and the releasing of rockets, bombs, or any combination of the three types and sizes of armament. This is accomplished by rotating the adjusting knob to one of two preset detent positions. Between missions, the detent positions may be changed easily to preset the sight for the offsets that will be required for other types and sizes of armament to be used during the next mission.

The detent device utilizes a friction brake. By use of the detent, the pilot may change the angle of inclination of the reflector plate without referring to the engraved scale on the gear housing surface. As he turns the knob he will actually FEEL the action of the detent device. He may then turn to the next detent position if he desires. The action of this device is similar to the action of changing stations on a television receiver.

Placement of the detent position is determined by the type of armament to be used on the mission, and is preset by the maintenance crews. The actual method of presetting is covered in detail in OP 1671 (Part 1), Change 1.

The importance of making the proper setting of the detent position may be realized by a knowledge of what a change in position means. As pointed out previously, the angle of inclination is determined by the armament used. Actually, it is the ballistic characteristics of the armament (rocket, bomb, projectile) that determine the trajectory once the projectile has been released or propelled from the aircraft. The inclination of the reflector is used in the Mk 20 Mod 4 to compensate for these ballistic characteristics. The missile will then hit the target if the proper compensation is used.

Gunsight Mk 9 and Mods

DESCRIPTION.—The Illuminated Gunsight Mk 9 and Mods (fig. 6–4) are illuminating optical reflector type gunsights

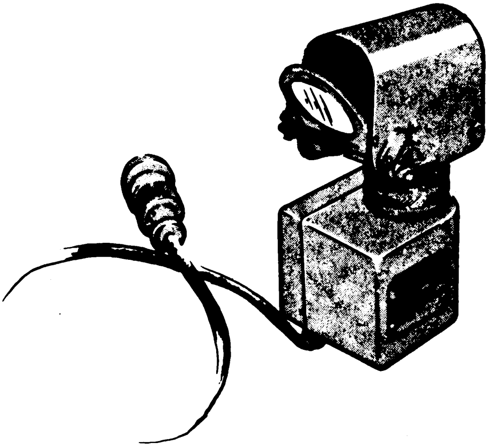


Figure 6–4.—Mk 9 illuminated gunsight.

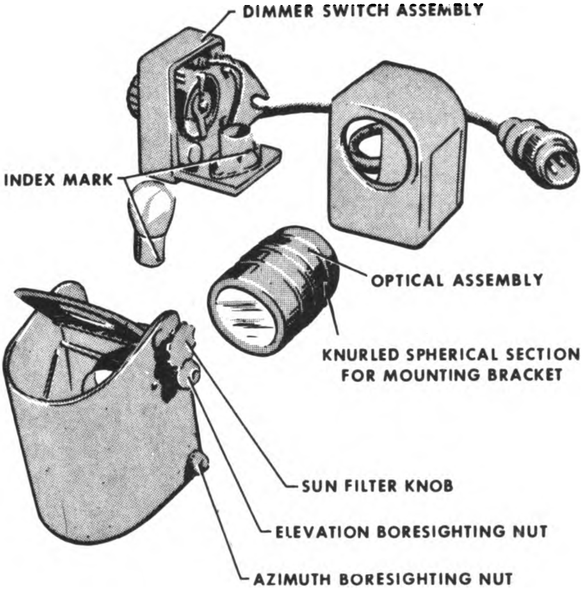


Figure 6–5.—Mk 9 illuminated gunsight, exploded view.

originally designed for use in flexible gunnery. The sight, when energized, projects a reticle pattern through the collimating optical system onto a glass reflector plate which is used in estimating leads in gunnery. The Mk 9 illuminated sight is presently being used in conjunction with the Mk 23 bombsight.

INSTALLATION.—The installation of the Mk 9 illuminated sight is a simple procedure. The concave spherical section of the mounting bracket is secured around the knurled spherical portion of the optical assembly. The clamping device is held in position by one bolt on each side of the sight clamping device.

The frosted area of the lamp (24 to 28 volts) should be pointed upward toward the reticle. Be certain that the switch is not in the NIGHT position while testing the lamp with the switch and rheostat. If the lamp is inserted incorrectly, the fixed resistor in the sight may burn out.

BORESIGHTING.—The boresighting adjustments are built into the sight, and the only tools needed to effect changes in azimuth and elevation are a 3/8-inch socket and a small screwdriver. Boresighting in azimuth is accomplished by loosening the nut on the right-hand side of the after end of the hood. (See fig. 6–5.) By inserting the screwdriver in the slot at the split of the after end of the hood base plate, the hood may be rotated to the desired azimuth position. When the correct setting has been made, the nut is tightened and the line of sight rechecked to see that it has not been altered in securing the nut. Boresighting in elevation is commenced by loosening the right-hand nut on the front end of the hood. Then move the boresighting cam on the left side of the hood and observe the line of sight. When it is in the desired position, lock by retightening the nut on the right-hand side and recheck alignment to make sure no movement or error has been made in the procedure.

MAINTENANCE.—The maintenance of the Mk 9 illuminated gunsight is limited to changing the lamps or checking to see if both lamp elements are good. Other maintenance consists of keeping the lens and reflector clean, and checking for broken or bent parts.

COMPUTING GUNSIGHTS

Gunsight Mk 18

DESCRIPTION.—The Gunsight Mk 18 (fig. 6–6) is a lead-computing gunsight, with which is combined an independent fixed sight. The lead-computing mechanism is an electromagnetically controlled gyroscope, and the computed lead is made visible in the operator's field of view by an optical system which employs a reflection from the gyroscope mirror. The gunsight automatically computes and makes the necessary lead and windage allowances for accurately hitting the target when the operator sets into the instrument the correct wingspan of the target, the correct altitude, and the correct indicated airspeed. The correct azimuth and elevation of the target relative to the gunsight position is set in by positioning of the turret. The operator must then accurately track the target.

To become familiar with the operator's view of the Mk 18 gunsight, one may imagine looking through the clear glass reflector plate (fig. 6–7) on which are reflected the images of two bright-line reticle patterns. Then by closing one eye

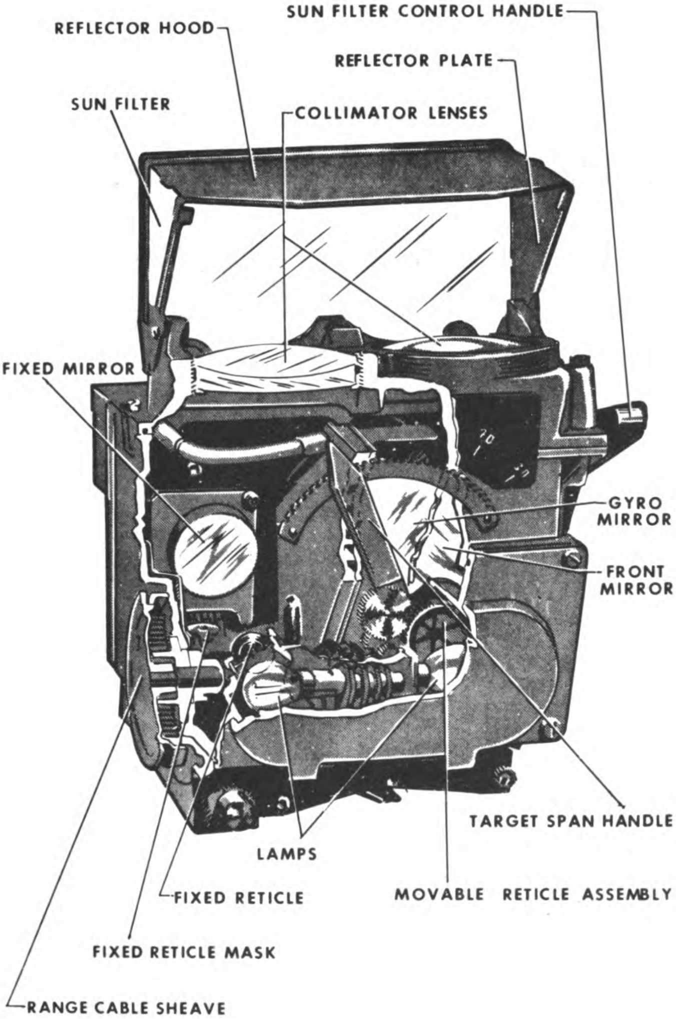


Figure 6–6.—Mk 18 gunsight.

the patterns are easily seen separately. With normal vision, looking through the sight at a distance, they seem as one, or superimposed at infinity.

The circle and/or cross reticle image (fig. 6–8) seen by the left eye is fixed and establishes a line of sight which is bore-

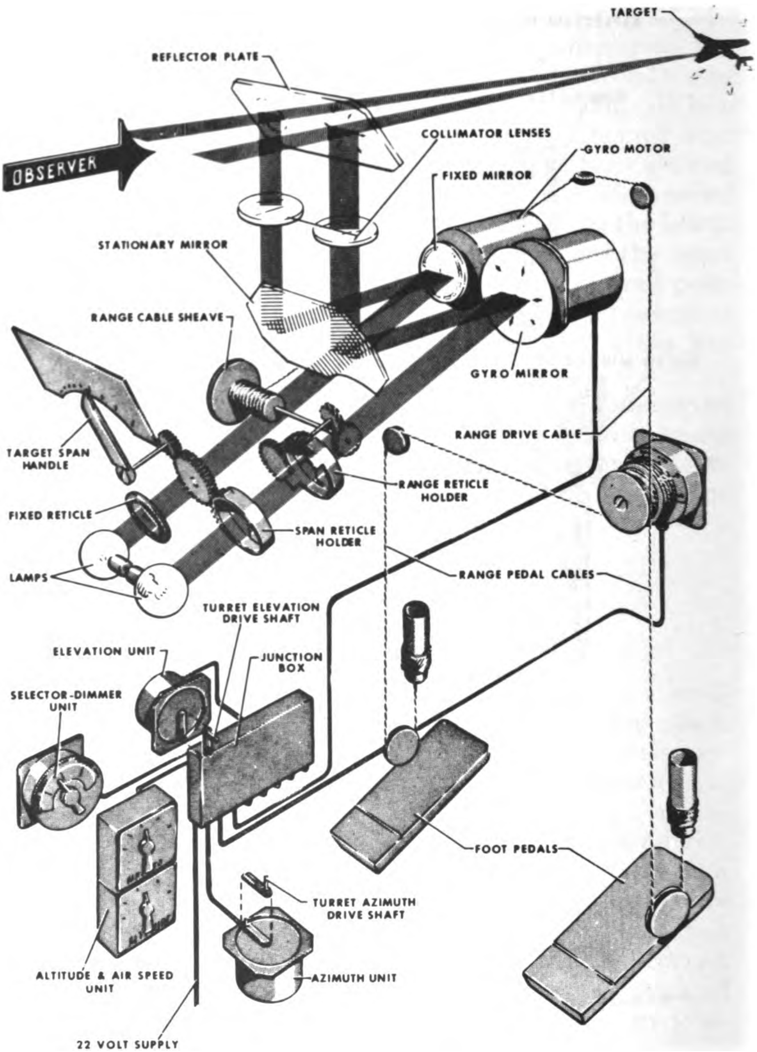


Figure 6–7.—Schematic diagram of sighting head and controls.

sighted with the guns. (The fixed sight reticle can be masked or unmasked.) The gyroscopic reticle image seen by the right eye is the lead-computer image, consisting of six radially disposed diamond-shaped dots with a round dot in the center.

To operate the sight while in flight, the operator may vary the distance of the diamond-shaped dots from the central dot in two ways. (See fig. 6–7.) One is by setting the span handle to the known wingspan of the target; the other is by operating the foot pedals. Both means may be used to obtain the range of the target. When the left-foot pedal (with the cable and sheave arrangement) is depressed all the way, the diamonds are as close to the central dot as possible. When the right-foot pedal is depressed, they are as far from the central dot as possible—that is, range is increased by the left-foot pedal range control, and decreased by the right pedal range control.

The objective of the operator is to bring the sight to bear on the target and to keep the inside points of the diamonds adjusted. They are adjusted so that the distance, between opposite pairs, exactly equals the wingspan of the target as the target comes within range and while it is being fired upon. When the operator has set into the instrument the correct values of altitude and indicated airspeed of his own aircraft, and has accurately tracked his target, the sight will automatically compute and compensate for the factors of operator's deflection and target deflection, windage or bullet trail, and gravity drop.

Operation.—In order to become more familiar with the Mk 18 gunsight, the components and theory of operation of each will be discussed.

The sight head is mounted on an antivibration mount designed to protect it from shock. The reticles (fig. 6–8) of the fixed and gyroscopic optical systems are mounted in the sighting head and are independently illuminated by two frosted lamps which are located on the lamp housing cover. (The frosted side of the lamps must be toward the reticle pattern because overbrightness from the unfrosted side will cause reticle image distortions.) Light from the gyroscopic reticle on the right-hand side, as viewed by the operator, is reflected from a flat mirror in the sight head. (See fig. 6–7.) It is then reflected through the collimating lens on top of the sighting head to the operator's eye by a clear glass reflector plate. The right-hand image therefore moves as the gyroscope is deflected. The optical path of the fixed sight (from its reticle on the left-hand side of the sighting head to the operator's eye) is similar to that of the gyroscopic sight with one exception. A flat stationary mirror, supported from the backplate of the gyroscopic unit is used for the first reflection instead of a gyro-mounted mirror.

The fixed reticle image is aligned by adjusting screws. The lenses are interchangeable in the fixed and gyroscopic reticle light path.

The RETICLE IMAGE of the left sighting system is formed by a 70-mil circle and central cross. (See fig. 6–8.) A mask with a small hole in its center is provided to permit the illuminated circle of the left reticle to be blanked out, leaving only the central cross visible. This mask is operated by a lever on the left side of the sight unit.

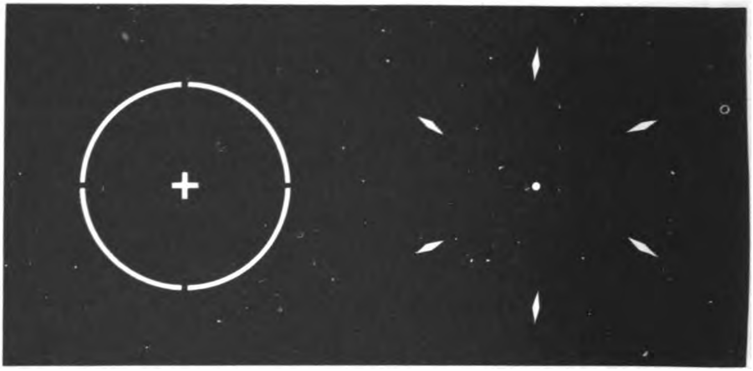


Figure 6–8.—Fixed and gyroscopic reticles.

The MIRRORS, except the transparent reflector plate on top of the sight, are aluminized on their front surfaces in order to prevent the ghost images which would appear if the light rays were permitted to traverse the glass.

A more detailed description of the gyroscopic reticle is of interest in explaining how it ACTS AS A RANGEFINDER. This reticle on the gyroscope side is formed by two suitably perforated thin metal disks, which are mounted very close together. These disks are aligned so that a beam of light can pass in a straight line through the central perforation in each. They are mounted individually so that each may be rotated by its own external control. The span disk has a central dot and six radial slits, and may be rotated by means of the span handle located on the front of the sighting head.

The other disk, the range disk, has a central dot and six spiral slits radiating from the center. It may be rotated by means of the range control. When these two disks are mounted in position on the axis of the optical system next to the lamp, the only points which pass light are the central dot and intersections of the radial and spiral slits. Thus, a reticle image is formed consisting of a central dot surrounded by six diamond-shaped dots in a circular pattern.

The differential motion of the two gyroscopic reticle disks governs the size of the circle of diamond-shaped dots. Thus, they provide a means for mechanically measuring range based upon the known wingspan of the target. The GYROSCOPE UNIT consists of a backplate upon which are mounted a fixed mirror, a small electric motor, a gyroscope rotor upon which a mirror is mounted, and a magnet pot (assembly containing electromagnets) which enables the gyroscope to properly compute leads and windage-offsets. The GYROSCOPE components (rotor-and-motor assembly) are mounted on a hub assembly (Hooke's universal joint). (See fig. 6–9.) The dome and stem assembly is coupled to a pulley which is, in turn, driven by a small electric motor through a coiled-spring belt.

The voltage regulator can be mounted anywhere convenient to the sight. Its purpose is to compensate for the fluctuations in the aircraft's 28-volt, d-c power, and the equipment's current drain. The regulator supplies constant 22-volt, d-c power to sight lamps, the gyroscope motor and coils, and the ballistic computer. The way in which this system computes and allows for BALLISTIC EFFECTS is described in two parts. First, the computation of angle of lead required for hitting a moving target is discussed. When energized, the range coils produce a unidirectional magnetic flux in the magnet pot. This flux is concentrated in the gaps between the four poles and hence in the spinning aluminum dome.

The eddy currents generated in the dome cause a drag on the dome. This drag produces a torque which always tends to make the gyroscope precess toward the effective center of the magnetic field. The rate of precession produced by this torque is independently proportional to two factors: the angular displacement of the gyroscopic axis from the center of the magnetic system, and the strength of

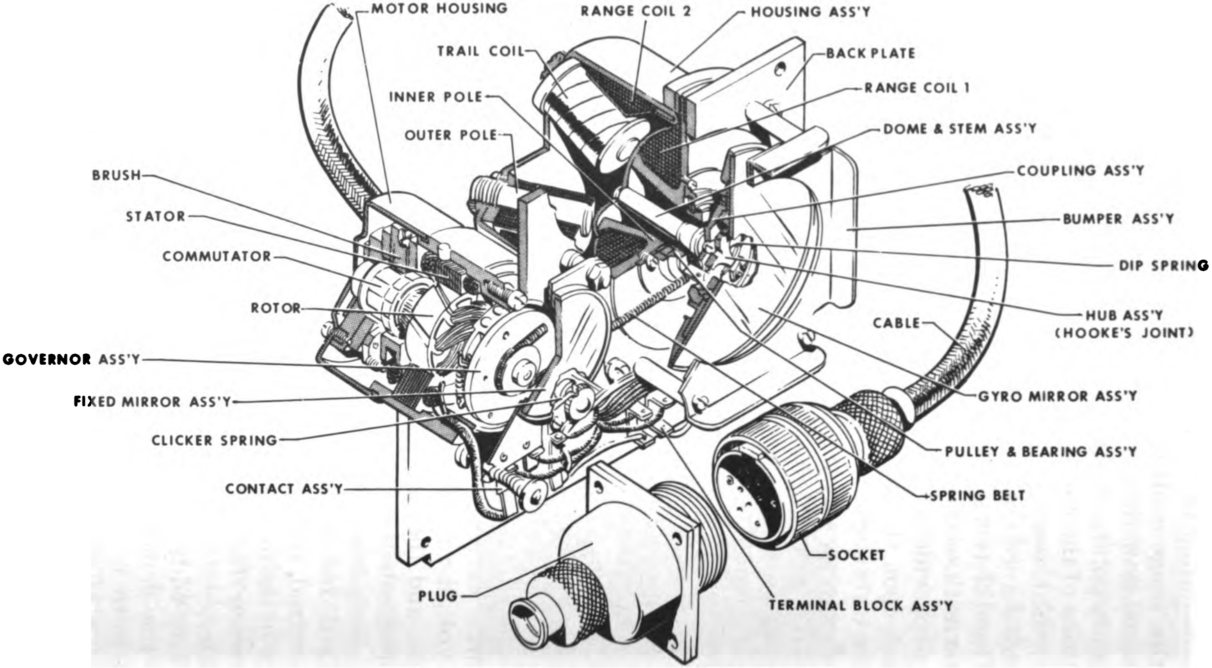


Figure 6–9.—Cutaway view of gyroscope unit.

the magnetic field. When the operator tracks the target at a certain angular velocity, the gyroscopic axis, trying in true gyroscopic fashion to maintain its direction fixed in space, lags behind the operator while tracking by an amount of angular displacement proportional to the angular velocity of tracking. This angular lag is sufficient to produce a precessing torque which, in turn, produces a rate of recession equal to the angular velocity of the operator's tracking.

The amount of this lag is controlled in part by the magnetic field strength in the aluminum dome, or by the current in the range coils. This range coil current is delivered by a range and altitude controlled electrical network which, in effect, makes the lag proportional to the bullet's time of flight to target. When tracking, the lag of the gyroscopic axis behind the operator is then communicated to the gyroscopic sight optical system as an angle of gun lead by the gyroscope mirror. This lead is proportional to the angular velocity of the target through the operator's tracking, and to the bullet's time of flight to target through the current in the range coils. The lead is then the correct amount to enable the operator's fire to hit the target. (See fig. 6–10.) **THE ANGLE OF GUN LEAD REQUIRED TO PRODUCE HITS IS EQUAL TO THE ANGULAR VELOCITY OF THE TARGET RELATIVE TO THE OPERATOR MULTIPLIED BY THE TIME OF FLIGHT OF BULLETS TO THE TARGET.**

The SECOND PART deals with computation of bullet trail, or windage. There are two azimuth coils wired in series opposition so that when a current flows through them the total magnetic field in one pole-gap is weakened. This causes a horizontal shift of the center of the magnetic field. The elevation and gravity coils act similarly; both produce vertical shifts of the magnetic field center. Since the gyroscopic axis always tends to align itself through the center of the magnet field, corrections for windage and gravity can be superimposed upon the lead computation merely by varying the currents in the azimuth, elevation, and gravity coils. These coil currents are properly varied by means of an electrical network containing controls for range, altitude, indicated airspeed, azimuth, and elevation.

In the RANGE CONTROL unit when the inside points of the image of the gyroscopic reticle exactly frame the target, the guns are within firing range. (See fig. 6–10.) The range control unit contains two variable electrical resistances, one

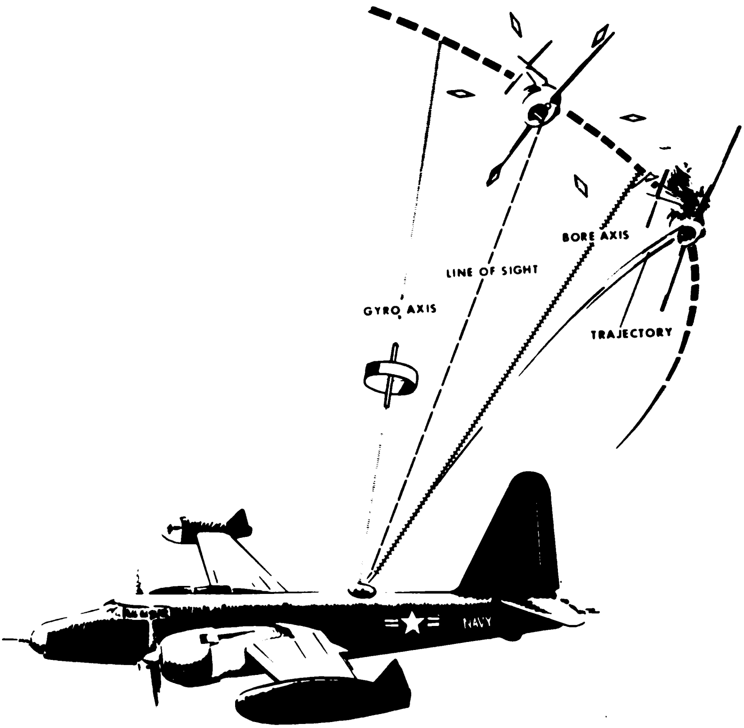


Figure 6–10.—Operation of gunsight.

of which controls current to the lead-computing coils of the gyroscope system, the other of which controls current to the remainder of the windage-computing network. The shaft which operates these variable resistances, carries a pulley which is driven by cables from the range pedals.

Although the altitude and indicated airspeed controls are electrically independent, they are built into the same unit. Both sets of controls contain variable resistances for altitude and airspeed which are manually preset by the operator before each engagement. The ALTITUDE CONTROL consists of two separate controls operated by the same shaft. The first one has a variable resistance in the circuit which feeds the lead-computing coils of the gyroscope unit. Its purpose is to compensate for gyroscopic responses that are the result of temperature changes caused by altitude variations. It also serves to make allowances for the decrease of bullet time of flight with increasing altitudes. The second part of the altitude control, consisting of a pair of properly related variable resistors, is in the windage-computing network. It merely modifies the windage coil current delivered by the range control, so as to correctly decrease the windage allowances as altitude increases.

The INDICATED AIRSPEED CONTROL, consisting of a pair of properly related variable resistors, is also in the windage-computing network. It merely modifies the windage coil current delivered by the altitude control, so that it properly increases with the airspeed of the operator's aircraft. It is calibrated so that if indicated airspeed is preset, it, in turn, sets true airspeed into the windage-computing network.

When using the Mk 18 gunsight in a turret the AZIMUTH CONTROL UNIT, consisting of several related variable resistors, is placed in the windage-computing network to modify the current from the airspeed control. It is geared to the azimuthal motion of the operator's turret, and so requires no presetting or other attention by the operator during its use. When the gunner fires at 90 degrees from the bow, either to the right or left, the windage deflection of his bullets is entirely lateral. Therefore, at azimuths of 90 degrees and 270 degrees, the azimuth control delivers maximum current to the azimuth coils of the gyroscope unit and zero current to the elevation controls. If the operator fires directly ahead or directly aft, his bullets are not deflected laterally, though they will be deflected in elevation if he either elevates or depresses his line of fire. Therefore, for these fore-and-aft azimuth positions, the azimuth control delivers zero current to the elevation control. In intermediate azimuthal positions, the azimuth control delivers intermediate current to both the azimuth coils of the gyroscope unit and the elevation control.

The ELEVATION CONTROL is in the windage-computing network and is geared to the motion of the turret. It does not require presetting by the operator. There are two suitably related variable resistors, which receive the current delivered to them by the azimuth control. These resistors modify the current with respect to the elevation, and pass it on to the elevation coils in the gyroscope unit. This modification consists essentially of passing zero current at zero elevation, maximum current at 90 degrees elevation up or down, and intermediate currents at intermediate elevations.

The elevation shaft has a dual purpose. It controls another variable resistor which modifies the gravity coil current with respect to the elevation. Gravity produces no deflections of the operator's bullets when he fires vertically upward or downward, but produces maximum deflections when he fires in a horizontal plane. This variable resistor allows maximum gravity coil current to flow at zero elevation and none to flow at 90 degrees elevation up or down.

MAINTENANCE.—When the sight is to be used, a preflight inspection should be made as follows: Inspect the surfaces of the reflector plate, collimator lenses, and sun filter, and clean them with lens tissue. The sun filter glass should be checked for operation by raising it into position to determine if it is out of alignment with the reflector hood. If it is too difficult to move, place a drop of oil on the operating lever pin and the fingers of the lever pin holders. Keep in mind that the operation of the lever should be a little stiff to protect the filter against vibration during flight.

Check the fixed reticle mask for freedom of movement.

Check the movement of the antivibration springs on the bottom of the sight to see if the movement is smooth. If not, oil the shaft bearing.

Inspect the silica gel frequently between checks; pink color of the silica gel means moisture is present, blue means no moisture present. (See fig. 6–11.)

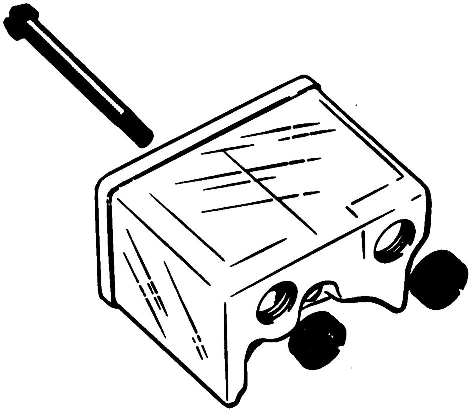


Figure 6–11.—Plastic silica gel cell assembly, exploded view.

Check the lamps visually for signs of blackening or change after each 5 hours of operation. CARRY SPARE LAMPS ON ALL FLIGHTS.

Check the movement of the span handle over the span dial for freedom of movement.

Turn on the sight and allow it time to warm up, then check to see if the gyroscope mirror has had time to assume its true axis of rotation. This can be checked by observing the gyroscopic reticle image. When the six diamond-shaped dots are clearly defined, and not fuzzy circles, the sight is ready for further use.

Check the range mechanism to see that there is no sticky or rough movement of the reticles or the mechanical linkage.

Check the reticle images with the selector knob set on the FIXED-AND-GYRO position. Sight on an object at least 500 feet away. Move the lamp rheostat to a comfortable image brightness. The reticle images should appear clearly defined and superimposed on the object without parallax. If the dots of the gyroscopic reticle image still appear round and enlarged after an initial warmup period, the gyroscope mirror probably requires balancing. Replace the sight if the gyroscope mirror needs balancing because this adjustment cannot be effectively made within the squadron.

Check for parallax in the sight by closing the right eye and examining the fixed reticle. Move the head from side to side and up and down over entire verticle range. If the CROSS RETICLE appears to move more than 2 mils, the sight should be replaced. Close the left eye and observe the gyroscopic reticle in the same manner. If the GYROSCOPIC RETICLE MOVES over 2 mils, replace the sight. For purposes of estimating the apparent movement of reticles, remember that the width of the central dot is approximately 2 mils.

Check the alignment of the fixed and gyroscopic reticles with the selector knob at the FIXED-AND-GYRO position, using an optical gage. This instrument keeps the eyes from crossing when both reticle images are observed at the same time. The optical gage also enables the maintenance man to make a rough check of the accuracy of the computing mechanism and the electrical control units while the sight is not in motion, but setting certain values into the gunsight.

ALIGNMENT.—The procedure given here described how to align the optics and boresight the sight with the guns in the turret. First, in aligning the optical systems, move the guns to zero degrees elevation. With the sight switch on, and the selector knob at the FIXED-AND-GYRO position, turn the rheostat to secure comfortable image brightness. Turn the airspeed control to the zero position. Manipulate the range drive system until the index mark on the sheave range scale is opposite the 1,250-foot mark. Secure the sheave in this position.

Remove the cover of the junction box and disconnect the green range wire. Then place the optical gage in position on the sight head. Observe the reticles. The image must be at the center of the cross of the fixed reticle image. If the central dot does not lie exactly on the center of the fixed cross, the fixed mirror on the backplate is out of alignment.

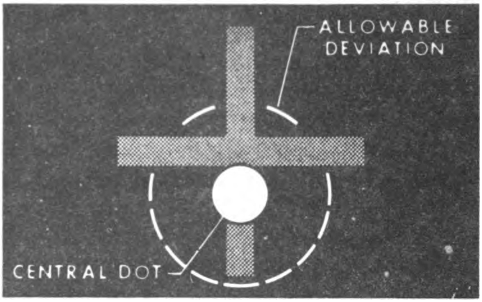


Figure 6–12.—Central dot in ideal position for alignment.

To align the mirror, remove the silica gel cell and adjust the two screws projecting from the backplate near the motor until the dot lies exactly on the center of the cross. (See fig. 6–12.)

When the sighting systems are aligned, release the sheave of the range unit and manipulate the range drive system to move the sheave slowly from maximum to minimum range. Observe the central dot and fixed cross. The dot should not move more than 2 mils. If it moves more than 2 mils, replace the sight head.

The fixed sighting system must be boresighted parallel to the bore of the guns. Keep in mind that it is not necessary to compensate for gravity drop of the projectile. The sight automatically does this. Use the boresight kit for aligning the guns with the boresight templet. When the point of aim of the guns has been satisfactorily established on a distant target, the point of aim of the fixed sight system must be aligned on the same distant target or the proper place on the templet. To adjust the line of sight in azimuth, loosen the screw in the bottom of the mounting bracket and rotate the sighting head to the desired position. The azimuth boresighting adjustment ring below the mounting bracket will permit adjustment of the line of sight to within a plus or minus 0.85 mils.

Gunsight Mk 18 Mod 6

The Gunsight Mk 18 Mod 6 is a lead-computing reflector-type sight, designed to compute and indicate the point of aim for either the caliber .50 or the 20-mm turret guns. The lead-computing mechanism is an electromagnetically controlled gyroscope.

The Mk 18 Mods 0 and 4 gunsights are practically identical. The Mk 18 Mod 6 is basically the same as the earlier modifications, but it does contain some features not found in the other modifications.

The most important modification in the Mod 6 is the change in the ranging servomechanism that replaces the cable-and-sheave range drive and simplifies the installation in turrets. The ballistic computer network in the Mod 6 may be adapted for either the caliber .50 or the 20-mm projectiles by means of a simple electrical connection which is made at the time of installation. Another improvement is the arrangement of the hand controls. The selector-dimmer, altitude, and airspeed control switches have been rearranged and mounted on a single control box. A TEST position has been added to the selector switch, and a test switch has been added to enable the gunner or the maintenance personnel to make image alignment checks and gyroscope friction tests without the necessity of disconnecting wires.

Other modifications include means by which to cage the gyroscope so that the turret may be slewed suddenly without tumbling the gyroscope. Also, provisions for controlling a recorder camera (Gunsight Camera Type CG-4) have been included. The camera is furnished by the Bureau of Aeronautics when required.

The Mod 6 also incorporates a temperature compensating circuit to correct errors introduced into the electrical circuits by changes in sight operating temperatures. Noise suppression elements have been placed in the range unit, voltage regulator, and gyroscope units. The chief advantage of the Mod 6 over the Mod 4 is the elimination of the mechanical range control cables used in the Mod 4. These range control cables are wire cables connecting the pedals with the range unit on the sight head, and a considerable amount of maintenance trouble has been encountered through their use. This has been eliminated in the Mod 6 by the use of the Range Unit Mk 18 Mod 0.

The Mk 18 Mod 0 range unit contains a servomechanism that varies the diameter of the gyroscope reticle image in accordance with the setting of a range control; and a range ballistic potentiometer that controls the lead, windage, and gravity allowances generated by the computing mechanism. The control of the Mk 18 Mod 0 range unit is maintained by the range control unit.

Rotation of the input shaft of the range control unit operates a ranging servomechanism that varies the diameter of the gyroscope reticle image and sets target range into the computing mechanism. The range control is mounted on the turret deck and connected to a ranging foot pedal so that the position of the pedal controls the position of an input shaft on the range control. This in turn controls the ranging mechanism, the gyroscope caging circuit, and the recorder camera control circuit. When the pedal is fully raised, the diamonds are as close to the center pip as possible (maximum range); when the pedal is fully depressed, the diamonds are as far from the center pip as possible (minimum range). When the pedal is fully raised, the gyroscope is automatically caged so that the turret may be slewed without tumbling the gyroscope. As the pedal is depressed slightly, as when commencing to range, the gyroscope is automatically uncaged, and the gun recorder camera may be placed in operation automatically to record tracking and firing results.

CONTROL SYSTEMS

Armament Control System Aero 5A

The Aero 5A armament control system is composed of an AN/APG-30 radar, a Mk 6 Mod 0 aircraft fire control system, an Aero 1A radar range servo, an Aero 2C gunsight controller, and an Aero 4C ranging throttle grip. Since certain elements of this armament control system are classified, it will not be discussed in this chapter. The Mk 6 Mod 0 aircraft fire control system, which is a component of this Aero 5A armament control system, is described in detail below.

Aircraft Fire Control System Mk 6 Mod 0

Description.—Aircraft Fire Control System Mk 6 Mod 0 is a pilot-operated fire control system for use in attack and fighter type aircraft. (See fig. 6–13.) It provides lead angle information for precision aiming of various fixed, forward-firing armament (guns and rockets).

This system makes use of a combined lead-computing and fixed sight. The target is viewed by the pilot through a clear glass plate on which are reflected two reticle images produced by two similar optical systems. The reticle images are focused at infinity and appear to be projected or superimposed on the target. The cross of the fixed reticle image establishes a fixed sight line which indicates the direction the aircraft is pointing. The center pip of the lead-computing gyroscopic reticle image establishes a sight line which is automatically offset from the fixed sight line at the proper angle for tracking the target. Using this image, the pilot's problem is simplified to pointing the aircraft so that the gyroscopic reticle image remains on the target, and following the sight line toward the target until the attack has been completed. However, the control settings of the system must be changed before various types of attacks, to be in accordance with settings specified for the firing or releasing of the respective stores.

Installation.—The Aircraft Fire Control System Mk 6 Mod 0 consists of the following components: Sight Unit Mk 8 Mod 0, Control Box Mk 20 Mod 0, Relay Box Mk 7 Mod 0, Switch Box Mk 3 Mod 1, Voltage Regulator Mk 1 Mod 0, Gunsight Controller Aero 2B, and Ranging Throttle Grip Aero 4B. Components of this gear are located in the most convenient position to the pilot. Those units which the pilot does not operate are located in various places throughout the aircraft.

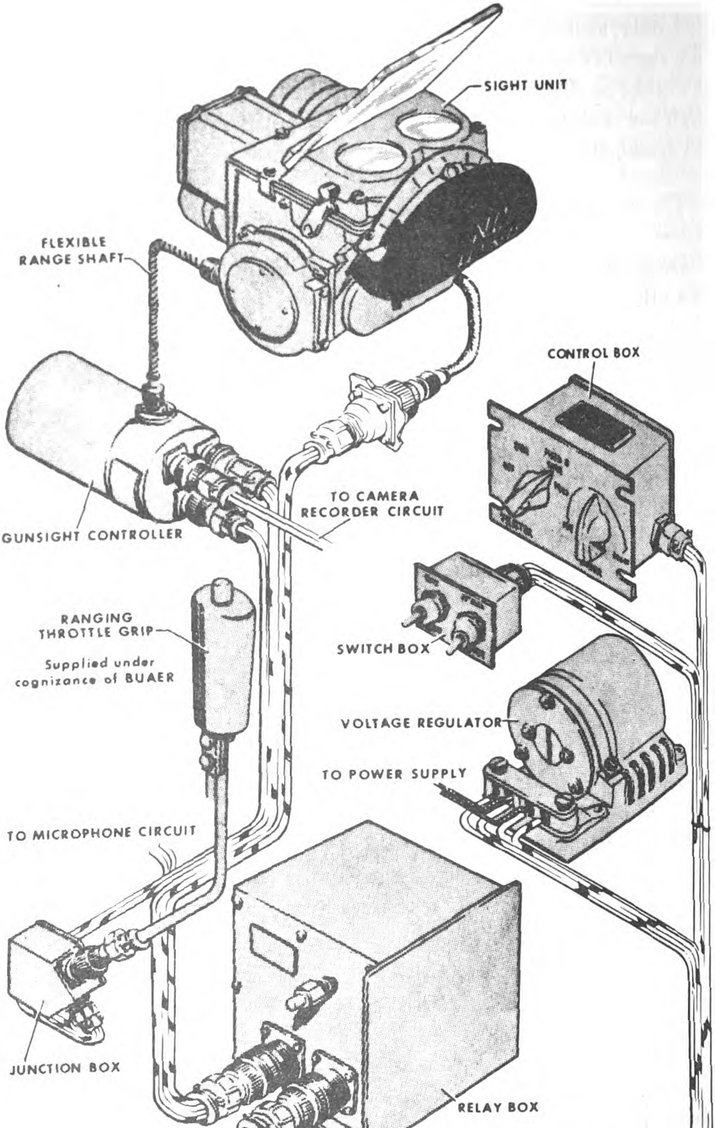


Figure 6-13.—Aircraft Fire Control System Mk 6 Mod 0.

Operation.—The operation of the Mk 6 aircraft fire control system is basically the same as the Mk 18 sight system. Those portions of the operation which correspond to the Mk 18 sight will not be repeated here. While changing from a turret operated system to pilot operation, some of the controls had to be eliminated. However, both these systems produce the same results.

The first noticeable change is the elimination of the foot range controls on the pilot operated system. To replace these, a Mk 17 Mod 0 range unit is attached to the sight. (See fig. 6–14.) It is attached to the controller (Aero 2B)

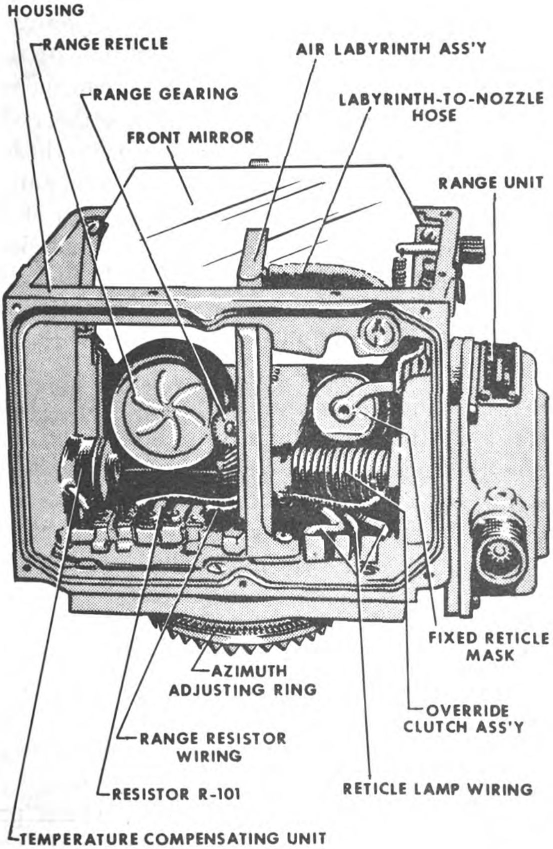


Figure 6–14.—Sight unit housing.

and energized by the ranging throttle grip Aero 4B. The **Mk 17 Mod 0 range unit** is attached to the left-hand side of the sight unit by four screws and a clamping ring. This method of attachment permits the range unit to be rotated around its lateral axis for alignment of the coupling with the flexible range shaft from the Aero 2B gunsight controller.

The **range unit** contains a pinion shaft (opposite the pinion gear) and has a splined coupling which mates with the flexible range shaft from the controller. The pinion gear meshes with a large drive gear at an 8 to 1 ratio.

The **drive gear** mounts the range dial and range resistor wiper arm. The range dial is visible through the window on the face of the range unit housing. The dial markings are for installation and checking purposes only, and need not be visible to the pilot for the operation of the system. As the drive gear is rotated, the wiper arm moves around the winding of the range resistor to vary the resistance of the circuit. This adjusts the input current to the range coils of the gyroscope in accordance with the target range.

The **range input sleeve** is driven by a pin on the range drive gear, which mates with a slot in the input sleeve. The sleeve is connected to the override clutch assembly in the sight housing, and contains an undercut section which engages the range stop to limit the rotation of the drive gear to range settings between 600 feet and 2,400 feet.

The **range reticle assembly** is driven by an override clutch assembly, a stadiometer range input shaft, and three gears. Since the stadiometer range input shaft is coupled to a drive gear in the range unit, any rotation of the drive gear will be transmitted through the override clutch assembly, the range input shaft, and range gears to the range reticle. (See fig. 6–15.)

The override clutch assembly permits the range unit drive gear to rotate after the gyroscopic reticle image pattern has expanded to its maximum diameter which is the minimum indicated range. As the target range continues to decrease the pilot continues to rotate the ranging throttle grip so as to decrease the range setting. When the range reticle assembly has been rotated to a position which produces a maximum pattern diameter, the override springs permits the

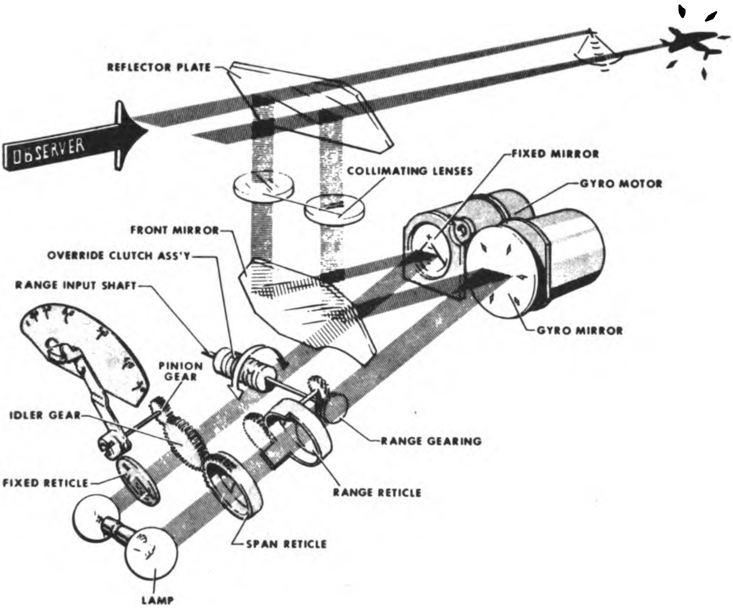


Figure 6–15.—Schematic diagram of optical system.

range input shaft to continue to rotate to minimum range position without further movement of the range reticle. If it were not for the override clutch, the range reticle would be jammed into its stops and damaged, or the span reticle setting would be disturbed. With the override clutch in operation, the diameter of the gyroscopic reticle image pattern stays the same, but the range unit mechanism can be turned to 600 feet without rotating the range reticle assembly. This permits the range resistor in the range unit to be set to the 600-foot position so the computer circuits can function properly at the minimum range for which the sight is calibrated.

To permit "breathing" by the sight unit due to air pressure variations during changes in altitude, the sight unit housing is provided with an air inlet through a labyrinth (a maze, full of intricate passageways), and a desiccating unit containing silica gel. (See fig. 6–11.) The silica gel dries the air entering the sight unit to prevent fogging of the optical surfaces. The labyrinth assembly consists of a long narrow tube contained in a wedge-shaped housing. The upper end of the laybrinth duct is connected to the silica gel cell by the labyrinth-to-nozzle hose. The silica gel cell is attached to the rear of the gyroscope mounting plate and is made of transparent plastic so that the color of the silica gel can be readily seen.

The purpose of the temperature compensating circuit is to provide a variable resistance. This resistance regulates the current to the range and elevation coils in the gyroscope so that it will compute accurate sight lines over a wide range of operating temperatures.

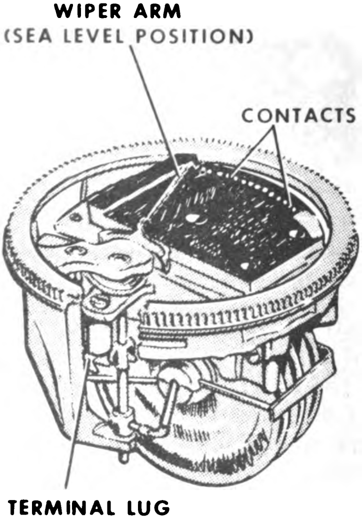


Figure 6–16.—Cutaway view of density compensating unit.

The compensating circuit consists of a resistor and the compensating unit. (See fig. 6–16.) The design of the circuit is such that the resistance of the network has a negative temperature coefficient; that is, as the temperature of the sight unit increases, the resistance of the compensating circuit decreases.

The temperature compensating circuit is connected in series with range and elevation coils in the gyroscope and operates in the following manner. The amount of restraining force imparted to the gyroscope assembly is directly proportional to eddy currents induced in the spinning dome in the gyroscope. As the temperature inside of the sight unit increases, the resistivity of the aluminum dome also increases. If the coil currents were fixed at a constant value, the increased dome resistivity would result in less current being induced in the dome. Therefore, there would be less restraining force on the gyroscope and an erroneous lead angle would be generated.

However, as described above, the resistance of the compensating circuit will decrease with an increase in sight operating temperature. Since the compensating circuit is in series with the gyroscope coils, an increase in temperature allows more current to pass through the compensating network to the coils. The increased current will compensate for greater resistivity of the dome and allow the gyroscope to compute accurate lead angles. As the operating temperature decreases, the resistance of the compensating circuit increases and functions in the reverse order from that explained above. Thus, as the resistivity of the dome varies with changes in the operating temperature inside the sight, the compensating circuit provides the gyroscope coils with varying amounts of current to keep the generated lead angles at the proper value.

The Aircraft Fire Control System Mk 6 Mod 0 makes use of the gyroscope to compute sight lines for aiming five-inch high-velocity aircraft rockets. The system provides two rocket circuits which furnish current to the range and elevation coils of the gyroscope. With the coils energized from either rocket circuit, the gyroscope will compute a sight line which, if held accurately on the target, causes the aircraft approach to coincide with the trajectory path of a 5″ HVAR.

In actual operation of the system as a rocket sight, the computation of the rocket sight line is similar to that for an aerial gunnery problem; that is, there is relative motion between the aircraft and the target. Due to the time of flight and trajectory of the rocket, the rocket must be aimed ahead of the target when it is released. As the initial flight path of the rocket is determined by the aircraft's flight path at the instant of release, it is evident that the aircraft must be aimed ahead of the target in order for the rocket to hit the target. Therefore, unless the aircraft is flying straight down toward the target, the sight line must be offset from the aircraft flight path during the rocket dive, at an angle which is equal to the time of flight of the rocket times the angular velocity of the aircraft relative to the target. In rocket operation of this system, ranging operation is not necessary.

When the rocket dive approach starts, the pilot aligns the aircraft so that the gyroscopic image is directly on the target. (See fig. 6–17.) However, since the sight line is depressed below the flight line, there will be a tendency for the sight line continually to move ahead of the target. To keep the gyroscopic image on target, the pilot must increase the dive angle slightly. In doing this the pilot has turned the aircraft and imparted an angular rate of turn to the gyroscope. This causes the gyroscope to lag and the gyroscopic image to move upward, necessitating an additional increase in dive angle in order to again bring the image on the target. Thus, during the approach to the target, the dive angle of the aircraft

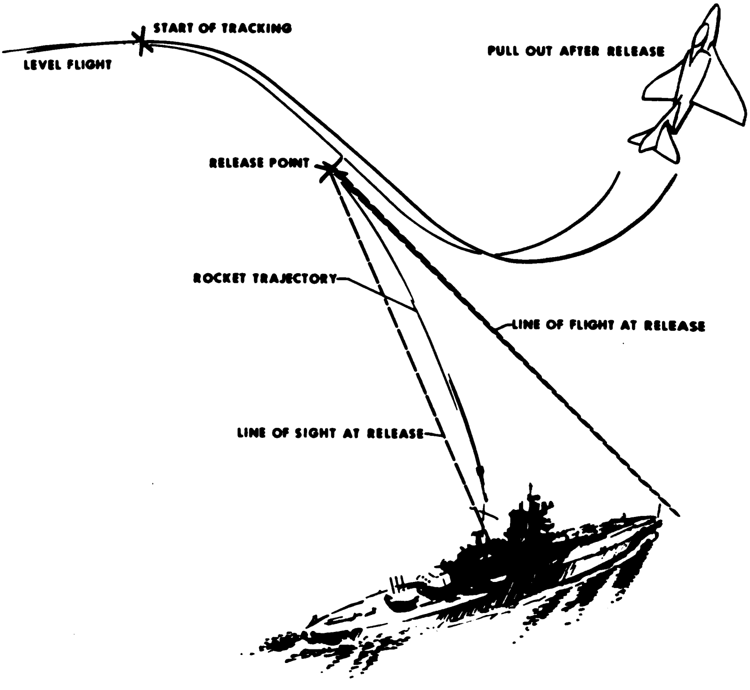


Figure 6–17.—Rocket firing.

is continually increasing and its flight path is the same as the trajectory curve for a 5″ HVAR.

In order to adapt the equipment for use in various types of aircraft with different dive charactertistics, the system is provided with a means of adjusting the sight line so that the flight path of various types of aircraft will be the same in the rocket dive. The flight paths are standardized by setting the sight to predetermined elevation offset values.

Elevation offset is produced by the two elevation coils. These coils, when energized, cause a vertical shift in the effective center of the magnetic field. This shift of the effective center results in a vertical displacement of the gyroscopic spin axis, thus causing the gyroscopic image to be deflected vertically. The amount of gyroscopic image deflection caused by the elevation coils depends upon the strength of the current through the elevation coils and upon the strength of the range coil current. The stronger the range coil current, the less effect the elevation coils will have.

In order to obtain maximum deflection over the nose of the aircraft, the fixed reticle image is adjusted a predetermined number of mils above the geometric center of the sight unit. The sight unit is mounted slightly nose down in the aircraft to align the fixed reticle image with the boresight datum line.

For operation as a lead-computing gunsight, the gyroscopic reticle image is initially brought into coincidence with the fixed reticle image. This is done by feeding a portion of the range coil current through the elevation coils, to produce the predetermined number of mils which the sight has been calibrated to offset, when used with rockets.

In ranging the target, the currents to both the range and elevation coils are varied proportionally so as to keep the calibrated offset superimposed upon the lead deflection.

For operation as a lead-computing rocket sight the gyroscopic reticle image is initially offset the required amount for the particular aircraft by supplying small amounts of current separately to the range and elevation coils. In tracking the target these currents remain constant so that the angular velocity of the aircraft controls the amount of deflection.

The **Mk** 20 **Mod** 0 **control box** provides a means for energizing the electrical circuits of the system, when selecting the desired reticle image and controlling the intensity of the selected reticle images. In this control box there are four settings of the master switch. The OFF position eliminates power from all circuits of the system. The GYRO position supplies power to all circuits except the fixed reticle lamp. This position is provided for the pilots who prefer to use the gyroscopic reticle image only when sighting on a target.

In the FIXED-AND-GYRO position, power is supplied to all circuits of the system and both reticle patterns are illuminated. The FIXED position supplies power to the fixed reticle lamp and the voltage regulator which, in turn, supplies the lamp. This provision is made in case the gyroscope system becomes inoperative.

The **Mk 1 Mod 0 voltage regulator** is a carbon pile type regulator unit designed for input voltages between 24 and 30 volts d. c. The requirement of this sight system is 22 volts plus or minus 0.3 volts d. c.

The **Aero 2B gun sight controller** is an electromechanical servo unit, the function of which is to drive the flexible range shaft connected to the range unit. The electrical circuit of the controller is designed around a Wheatstone bridge circuit. The basic elements of which are a servo relay, a response potentiometer, and a control potentiometer. The control potentiometer is located in the ranging throttle grip and connected to the response potentiometer by cabling. The resistance settings of the response potentiometer are varied by means of a rotating contact which is coupled to the servo gearing driven by the reversing servomotor. The balanced servo relay, when energized, controls the direction of rotation of the servomotor, and hence the direction of rotation of the servo gearing which drives the flexible range shaft.

Range limit cutout switches, operated by cams in the servo gearing, interrupt the power to the servomotor when the range has been driven to the minimum or the maximum. At maximum range, a caging switch is closed and supplies power to the caging relay in the relay box. Another switch in the controller is also provided for operating a gun camera circuit. The caging switch is open and the camera switch closed at any range setting for which the system is usable.

The **Aero 4B ranging throttle** grip is used in the system as the pilot-operated ranging control. The grip is designed to be mounted on the engine throttle lever. Rotation of the grip about the axis of the throttle lever moves a contact arm on the control potentiometer and thus varies the resistance settings of the potentiometer.

The grip aso contains a pushbutton switch which can be connected into the microphone circuit of the aircraft transmitter.

The Mk 7 Mod 0 RELAY BOX used in this system provides current limiting circuits which supply the range and elevation coils of the gyroscope with the proper amounts of current. Since the positions of the gyroscope and the gyroscopic sight line are controlled by the coil currents, the relay box adapts the system for multipurpose use.

The DENSITY COMPENSATOR UNIT is located in the relay box. (See fig. 6–16.) The unit provides automatic corrections to the gyroscopic sight line for trajectory variations caused by changes in air density with changes in altitude. The amount of corrections supplied by the unit is inversely proportional to the ambient (surrounding) air density. Namely, at low altitudes, the density is greater and the time of flight of the projectile is greater than at high altitudes. Therefore, at low altitudes, greater lead angles are required. The compensator unit operates only when the system is used as a gunsight.

The COMPENSATOR UNIT is essentially a standard altimeter which has been modified by adding a tapped resistance winding the fixed contacts and a sliding contact attached to a wiper arm. The wiper arm is moved by the barometric element of the altimeter so that the active resistance of the unit varies with altitude. At low altitudes the resistance is high, and as the unit moves to higher altitudes the resistance drops proportionately.

SWITCH BOX MK 3 MOD 1 is used only with the Mk 6 Mod 0 fire control system and provides a means of selecting either gun or rocket circuits. This switch box also provides for the selection of the dive angle; over 35° or under 35°.

MAINTENANCE.—The maintenance of the Mk 6 Mod 0 sight system necessitates a thorough check every day the sight is in use. When the sight is not in use, the cover should be kept over the head and the silica gel cell should be checked periodically for moisture content.

To maintain the sight, a spare parts set is needed. It should be kept filled and the parts should be kept usable. The optical gage should always be kept handy for use. The test unit for the controller is very important. Modifications to the unit should be made immediately upon receipt. A usable volt-ohmmeter is the most important part of the checking equipment for the sight circuits. The re-oiling equipment is used for lubrication of the sight head. The Mk 19 Mod 0 test unit for the sight system is used to check the deflection of the gyroscopic reticle.

The check periods for this equipment depend on how much it is used and how it is handled. In a squadron in which all personnel realize the value of the gear, misuse and abuse of the equipment will be kept to a minimum. Do not use the sight head for a handhold on entering or leaving the turret, and use only the specified cleaning equipment and solutions. Otherwise, damage will result to the sight optical system. Frequent arrested landings and rough field landings affect the accuracy of the fire control system. Regular tests should be made on this gear to determine its serviceability.

Aircraft Fire Control System Mk 6 Mod 3

The Mk 6 Mod 3 aircraft fire control system is the latest in the Mk 6 series. It is similar to previous modifications, and uses many of the same components as earlier versions of the Mk 6. Aircraft Fire Control System Mk 6 Mod 3 differs from earlier Mods in that the converter Mk 31 Mod 0 replaces the Gunsight controller Aero 2C and the Radar Range servo Aero 1A which were used in earlier radar ranging versions. As in the earlier modifications, stadimetric ranging can be utilized if desired or needed.

Another change to the Mod 3 is the provision of a tone circuit to indicate when the target is within firing range. The means of caging or uncaging the gyroscope at any time is also available, and an adjustable reflector is incorporated to permit the use of the system with different types of armament.

Radar ranging.—The equipment added to provide for radar ranging is the Range Data Converter Mk 31 Mod 0. This electronic device is connected with an AN/APG–30 radar set and components of the Mk 6 Mod 0 aircraft fire control system to create the Mk 6 Mod 3 aircraft fire control system. When the range data converter is installed, all components of the Mk 6 Mod 0 are used except the Mk 8 Mod 0, or 5, sight unit, which is replaced by the Mk 8 Mod 9 sight unit. Also, the gunsight controller is eliminated.

The range data converter takes from the radar a linear direct current voltage which corresponds to range variations, and converts it into a nonlinear direct current which is modified for temperature and altitude variations. The modified direct current is then supplied directly to the range and elevation coils of the gyroscope. With the proper range current supplied to the gyroscope, the sight unit will provide the proper lead for firing the guns in air-to-air operations.

The range data converter also contains a tone generator circuit. When the radar locks on the target, this circuit generates a 400-cycle tone which is heard through the pilot's headphones. As the pilot tracks the target, range voltage decreases. At some preset value, which is equivalent to a preset range, the tone generator changes the tone to one of 800-cycles. This 800-cycle tone continues throughout the firing range. When the pull-off target range voltage reaches a second preset value (minimum range) the tone generator circuit is restored to its original condition causing the audio signal to change back to 400 cycles.

Stadimetric ranging.—Since the converter supplies the proper range current to the gyroscope, the use of this equipment does not require the pilot to set the estimated target dimension into the sight by means of the target span lever. However, provision is made for the pilot to set a fixed range current value into the sight unit by means of a manual ranging knob located on the left-hand side of the sight unit.

To use the manual ranging knob, the radar switch must be set to the STANDBY-MANUAL or OFF position and the target span arm must be set to the known or estimated target dimension. Turning the manual range knob adjusts the diameter of the diamond-shaped pips to agree with that which is established for the usual stadimetric ranging problem. The manual range knob also positions the resistance potentiometer so that proper range current is supplied to the gyroscope for the selected fixed range. The firing range may then be estimated by using the diamond-shaped pips of the gyroscope reticle image. The tone alerting system does not function when operating manually.

CAGING THE GYROSCOPE.—Because the ranging throttle grip does not adjust the diameter of the pips as in other modifications of the Mk 6, it had to be modified for use in the Mod 3. The result is a grip that is used ONLY as a caging switch. By using this switch, the gyroscope may be caged or uncaged at any time.

OPERATION.—The Mk 6 Mod 3 aircraft fire control system is a versatile piece of equipment. It can be used for radar ranging for guns, manual ranging for guns, firing rockets, and bombing operations.

When using this equipment for radar ranging for guns, the radar is used to supply the range of the target. Once the radar has locked on a target, the automatic alerting system will emit the 400-cycle note. The volume of the tone may be adjusted by the pilot. After target lock-on, the gyroscope should be uncaged and smooth tracking of the target commenced. The range data converter automatically and continuously supplies range data directly to the sight unit so that the proper lead is generated. When the firing range is entered, the tone should change to an 800-cycle tone and remain at 800 cycles throughout the firing range.

When using the Mod 3 for manual ranging for guns, the radar is not used. Range is determined stadimetrically. This is accomplished by setting the estimated target dimension in the sight by means of the target span lever. Then the fixed range for firing is set into the sight by the manual range knob which is located on the left-hand side of the sight unit. Finally, the gyroscope is uncaged, and tracking of the target with the gyroscope reticle image is started. At the proper estimated range, the firing is commenced. In this operation there is no continuous ranging of the target, and the aural tone alerting system does not operate.

The Mk 6 Mod 3 aircraft fire control system is also used for rocket firing. When used for this purpose, the radar is not put in use, and no ranging operation is necessary. The rocket circuit of the Mk 6 Mod 3 is the same as it is for the Mod 0 system. With the proper offset in the system and the armament switch in the proper position, the equipment computes the correct lead for firing rockets at stationary or moving ground targets. In addition to computing the lead, the system compensates for wind and target motion.

The rocket offset is called the "beta offset" and is defined as the amount the gyroscope is depressed below the armament datum line for a positive offset, and raised above the armament datum line for a negative offset. This offset is expressed in mils and is primarily dependent upon the angle of attack of the aircraft's armament datum line, dive angle, speed, range to the target, type of rocket being fired and the rocket launcher angle. In the Mod 3 system, the proper offset for the armament is set into the equipment by the use of an adjustable reflector plate. The selection of the correct offset position is accomplished by an adjusting dial located on the right-hand side of the sight unit.

Armament Control System Aero 10B

The Aero 10B armament control system consists of an AN/APG–30 radar, and the Mk 16 Mod 2 aircraft fire control system. Certain elements of this armament control system are classified, and therefore will not be discussed in this chapter. It will be noted that the Mk 16 Mod 2 aircraft fire control system, which is a component of this Aero 10B armament control system, is described in detail below.

Aircraft Fire Control System Mk 16 Mod 2

DESCRIPTION.—The Aircraft Fire Control System Mk 16 Mod 2 (fig. 6–18) is an automatic lead-computing, pilot-operated system designed for aiming the aircraft in the fire control of fixed, forward firing guns and rockets. The fire control advantages provided by the system are not limited to any one type of armament. The system will accurately compute the point of aim for any service type of gun and rocket in either air-to-air or air-to-ground combat. Gun or rocket ammunition changes are incorporated into the system by the substitution of appropriate plug-in ballistic elements. The system can be transferred from the control of gunfire to rockets, and from air-to-air to air-to-ground operations at the option of the pilot by means of suitable selector switches on a control box.

The point of aim, computed by the system, is indicated to the pilot by means of a reflector type sight unit which provides two reticle images. (See fig. 6–19.) One is a fixed image which indicates the direction that the guns are point-

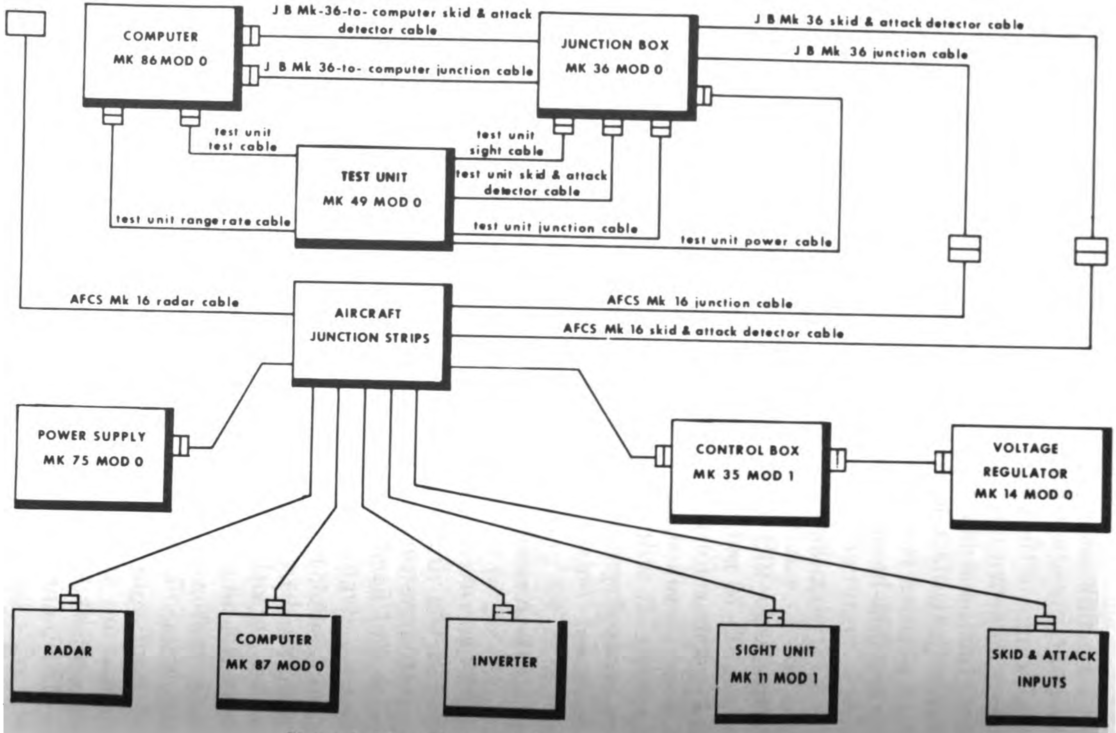


Figure 6–18.—Diagram of system with test unit attached.

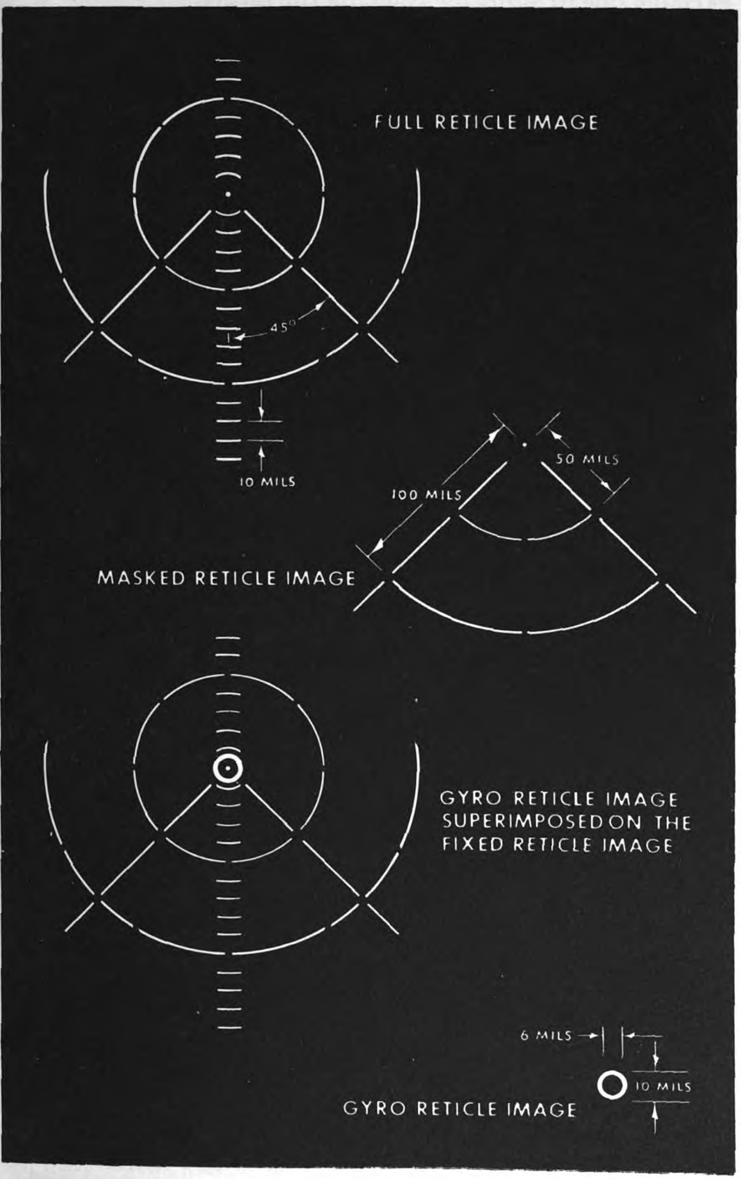


Figure 6–19.—Fixed and gyroscopic reticle images.

ing, and the other is a gyroscopic image which establishes a variable line of sight for tracking the target.

In the operation of the system, after the initial settings have been made on the control box, the pilot is free to concentrate on the tracking of the target.

During the approach to the target, the gyroscope in the sight unit is caged to prevent it from tumbling. The pilot approaches the target until the on-target lamp goes out. This indicates that the target is within range, as a result of the radar having located the target. The pilot then estimates the target lead and maneuvers the aircraft to lead the target accordingly, using the gyroscopic reticle image as a reference. The gyroscope is then uncaged and the gyroscopic reticle image moves to the correct point of aim on the target and remains there, assuming that a correctly estimated lead angle was established with the gyroscope caged. The pilot makes the necessary flight corrections to maintain the gyroscopic reticle image on the point of aim of the target during the entire tracking run. While the pilot concentrates on smooth tracking of the target, the system continuously offsets the sight line to the proper angle necessary to score a hit. This offset is varied by the fire control system to compensate for range, range rate, relative target motion, time of flight, windage, gravity drop, air pressure, and skid and attack angles.

The fighter aircraft is at all times maintained in a correct firing position as long as the pilot tracks smoothly and holds the gyroscopic reticle image on the point of aim of the target. This condition is illustrated in figure 6–20 which shows a fighter plane closing the range during a typical attack upon a target. The fire control system automatically calculates the lead between the line of sight, and the line of fire, as long as the target remains within the range of the system. After a period of smooth tracking, the pilot may fire at any time that satisfactory firing conditions exist.

The ballistic constants required by the computer circuits of the system for the stores to be used are preset before flight by inserting suitable plug-in ballistic elements. (See fig. 6–21.) There is a separate plug-in unit for each type of gun and for each type of rocket. Only one type of gun and one type of rocket may be used with the system on any one flight.

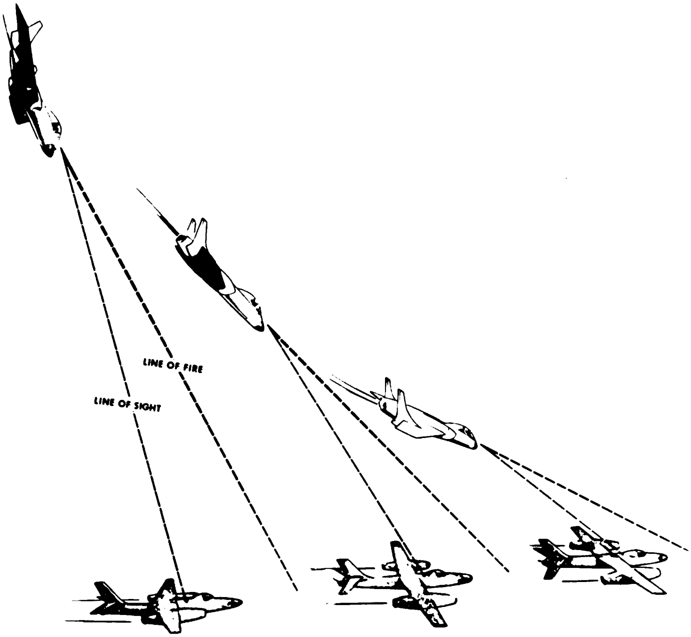


Figure 6–20.—Typical air-to-air attack.

The Fire Control System Mk 16 Mod 2 is normally used with automatic radar ranging for air-to-air or air-to-ground combat when the target is suitable for this type of ranging. When conditions are such that the target is not suited for radar ranging, the pilot may manually select a fixed range, determined by his judgment, through the use of a dial provided on the control box.

SYSTEM DESIGN ADVANTAGES.—The Mk 16 Mod 2 system makes use of potted components built up around magnetic amplifiers and transformers. The potted units are free from the vibration, filament, or emission failures typical of the electronic type of computer. Potted components in this instance are self-contained elements of an electronic circuit which are fitted into a container and plug into the basic piece of gear with which associated. The resulting system is rugged and requires less maintenance than previous systems

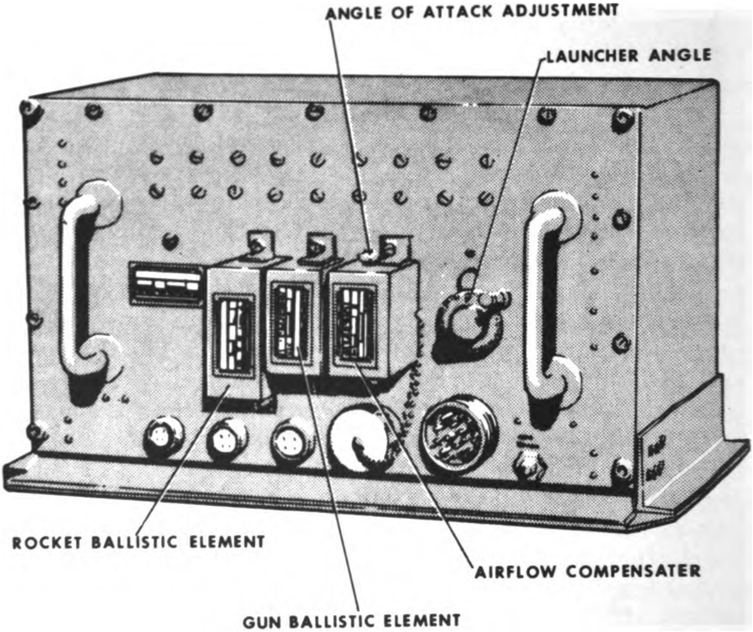


Figure 6–21.—Computer Mk 86 Mod 0 with ballistic element and airflow compensator.

having similar functions. The system also features the use of the phase balance computed as a computing element offering an average error of less than 0.8 percent. Plug-in (potted) units are used throughout the system where possible, permitting the rapid replacement of circuit elements. The range and range rate servo units have been replaced by circuits having no moving parts. The system is very flexible with respect to armament, since the fundamental ballistic data for a rocket or gun is furnished by a plug-in ballistic element which can be furnished when required for present or future guns or rockets.

Operation.—The Fire Control System Mk 16 Mod 2 should be inspected frequently to see that it is in proper operating condition. Some of the troubles can be found by a general preoperation check. Connections, bulbs, positions of various switches, unit interconnections, and cleanliness of sight and windshield should all be checked prior to actual operation of the system.

The Mk 16 Mod 2 fire control system is comparable in certain respects to the Mk 6 Mod 0 fire control system and the Mk 18 fire control installation. The sight head of all three have double reticles and fixed and gyroscopic operated reticle images. The information needed by each sight head is the same but the method by which it is obtained has been made progressively less manual. Radar is now tied into the fire control system so that more of the operation is left to the computer and less time has to be devoted by the pilot in manually operating the system. This has become necessary due to the speeds at which the aircraft now fly.

To operate the fire control system, turn on the gear for a warmup period of at least 30 seconds. The gear becomes more accurate as it nears its normal operating temperature.

After the initial warmup period the sight is ready for use in air-to-air attack. Turn the console lighting switch to the ON position. Turn the radar power switch to the ON position. Set the guns-test-rockets switch to GUNS or to ROCKETS, depending on the armament to be fired. Set the range switch to the RADAR position, if automatic radar ranging is desired. In the event that the radar system is inoperative, or a fixed range is desired, set the switch to the FIXED position and align the fixed range dial to the desired range value. This range dial is calibrated.

Turn the gyroscope lamp switch (and the fixed lamp switch if the fixed reticle image is desired) to either of their ON positions. Rotate the bright-off dial clockwise until the reticle images are illuminated for proper visibility.

Alternate ON switch positions are provided for the gyroscope and fixed lamp switches to energize the second set of filaments in the reticle lamps. When either one or both of the reticle images do not appear on the reflector plate upon completion of setting the brightness desired, move the applicable switch to its alternate ON position.

When it is desired to use only the central point of the fixed reticle image, the outer markings of the image can be masked by pulling out on the fixed reticle selector knob. Make sure that the caging switch is in the CAGED position. The system is now ready for use.

Ground checks.—The Mk 16 Mod 2 aircraft fire control equipment should be tested and inspected frequently to insure that the system is in good operating condition. The procedure for a ground check of the system is described below. The inspection is to be followed by repairs and replacements where they are required.

All components of this system should be examined for evidence of physical damage and for sources of possible interference with its operation. The principal items to be checked are:

1. Check to insure that all cables are routed so that they do not touch sharp edges or rough surfaces.
2. Insure that none of these cables are frayed, broken, or have become oil soaked.
3. Check for dirt and oil on equipment, connectors, and exposed current carrying parts of the equipment.
4. Check for loose or improperly secured wiring or cabling.
5. Check for articles adrift in the equipment such as tools and spare parts.
6. Inspect the mounting bolts on the bases and on all subassemblies for tightness.
7. Inspect all lock rings on the connectors for tightness.
8. Insure that all locking screws on the equipment are tight.
9. Inspect the equipment for scorched, rusted, or fractured areas which may indicate possible damage from heat, excess moisture, or vibration.
10. All shock mounted units in this equipment should be checked for free operation and movement. The retaining screws of all vibration mounts and their associated units should be checked to insure that all parts are securely fastened in place. Tighten all loose bolts and replace all defective mounting screws.
11. Test all of the switches which control the fire control system for smooth and positive mechanical operation.
12. Inspect the silica gel cell which is mounted on the side of the Sight Unit Mk 11 Mod 1 for proper blue color of the gel. The purpose of the silica gel is to keep the interior of the sight housing free from moisture to prevent fogging of the optical surfaces. When the silica gel becomes saturated with moisture, it becomes pink in color. If the color of the silica gel does not remain blue after four flights, the sight must be removed and forwarded to an overhaul activity.

13. Make an inspection of each side of the windshield, reflector plate, and the top surfaces of the collimating lens. If these surfaces are dusty they may be cleaned with a fine grade of camel's-hair brush, or by wiping gently with lens tissue. If these surfaces are dirt streaked or smeared they may be cleaned with a soft clean cloth, or with lens tissue moistened with a suitable solvent such as lens cleaner or alcohol. Avoid touching any of these optical surfaces with the fingers.

COMPUTER MK 86 MOD 0.—This computer receives all the inputs required for the calculation of the lead, and delivers appropriate direct currents to the Sight Unit Mk 11 Mod 1. The computer does not contain any pilot operated controls and its function is to furnish the sight unit with the following currents: RANGE CURRENT, which determines the sensitivity of the sight unit for proper kinematic lead; ELEVATION CURRENTS, which supply compensation for trajectory drop, launcher angle, and angle of attack; and the AZIMUTH CURRENTS, which supply compensation for angle of skid.

The computer functions for guns or for rockets by receiving suitable voltages representing terms in the fire control equation that are to be solved. These input voltages are subjected to the necessary mathematical processes by the operation of the various computer circuits. The resulting outputs represent the correct answers to the problems presented by the target to the fighter plane during its pursuit course.

The computer calculates time of flight of the projectile from voltages that are proportional to the average velocity of the projectile, and from input voltages proportional to range and range rate. The voltage that is proportional to the average velocity of the rocket is calculated from inputs which are proportional to the rocket burning time; air pressure, supplied by the pressure transmitter; aircraft velocity, supplied as a function of the hand set aircraft velocity switch; and ballistic constants, furnished by the plug-in ballistic units. The time of flight voltage is also used in this calculation.

In the case of guns, a constant input is used which is proportional to average velocity without air drag. The computer also calculates the gravity lead from the time of flight and from appropriate ballistic constants furnished by the

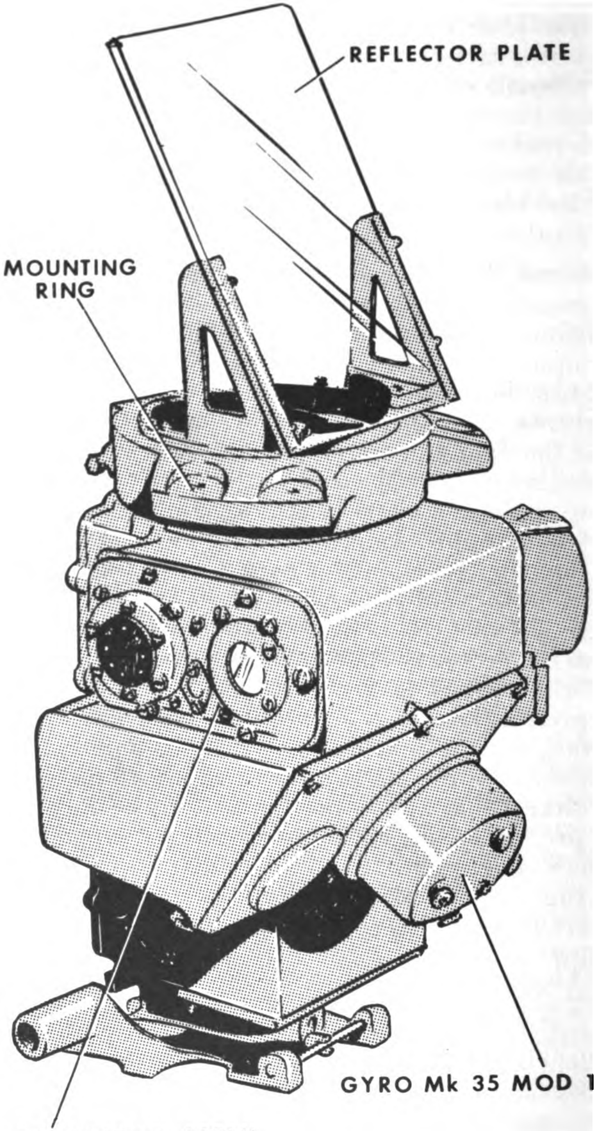


Figure 6-22.—Sight Unit Mk 11 Mod 1.

ballistic plug-in units. The computer calculates the true angle of skid and the true angle of attack from input supplied to the airflow compensator by the airstream direction detectors as well as from the values supplied by the airflow compensator unit. The range current to the sight unit is calculated from the inputs of range and other voltages representing average velocity and the sight unit dome temperature function. The elevation currents to the sight unit are calculated from inputs from the accelerometer and from the angle of attack detector along with proper computation of voltages proportional to gravity lead, launching factor, launcher angle, and range current. The azimuth currents to the sight unit are calculated from the input from the angle of skid detector and the voltage proportional to the range current.

Sight Unit Mk 11 Mod 1 (fig. 6–22) is similar in operation to the Mk 18 Mod 0 with the fixed image being directed through the same lens as the gyroscopic image, although the fixed and gyroscopic images are still individually illuminated. There are changes in the sight which help produce a more accurate computation with the added units in this system. For detailed information, see the pertinent Ordnance Data instructions.

Computer Mk 87 Mod 0 (fig. 6–23) is an electronic computer with a self-contained power supply. It computes the range rate voltage from the radar range voltage.

Voltage Regulator Mk 14 Mod 0 (fig. 6–24) maintains the voltage supply for the two lamps in the sight unit within the limits necessary to prevent sudden changes in intensity of illumination due to power fluctuations. The voltage regulator is made up of an individual voltage regulating circuit for each lamp. The output of each of these magnetic amplifier regulating circuits is controlled by a rheostat mounted on the control box. Two rheostats are ganged to a common shaft which is operated by the bright-off control dial. Through the use of this dial, the pilot may adjust the brilliancy of the lamps in the sight unit to the desired level. The regulator circuit maintains the lamp voltage at the particular point selected. The voltage regulator is made up of potted assemblies and one VR (voltage regulator) tube.

Control Box Mk 35 Mod 1 (fig. 6–25) houses all the con-

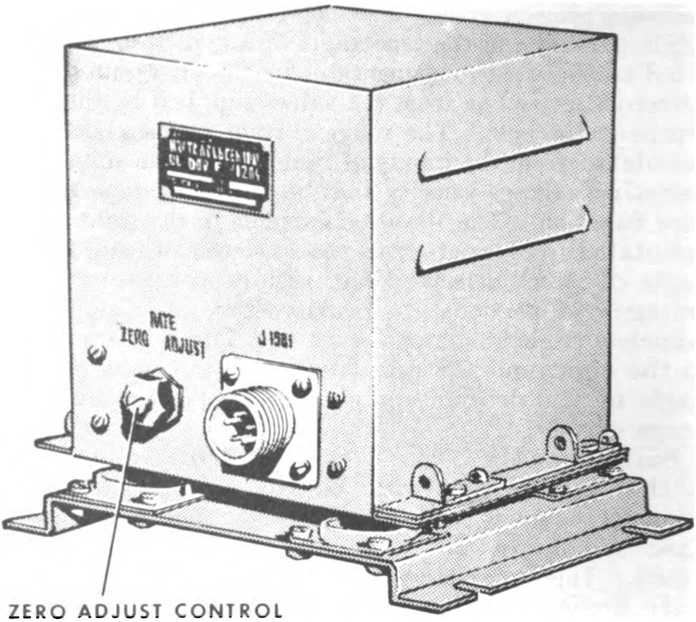


Figure 6–23.—Computer Mk 87 Mod 0.

trols needed by the pilot to control the Mk 16 Mod 2 aircraft fire control system during flight. The controls of this unit are: the bright-off dial, the two-position range switch marked RADAR-FIXED, the fixed range dial, the three-position toggle switch marked GUNS-TEST-ROCKETS, the gyro lamp switch, with three positions marked ON-OFF-ON, and the fixed lamp switch. This control box is illuminated by two lamps connected to the console lighting circuit.

Power Supply Mk 75 Mod 0 (fig. 6–26) contains a selenium rectifier and associated power transformers arranged for three-phase operation from the a-c output of the system inverter. The power supply furnishes the d-c supply for the gyroscope motor in the sight unit.

Ballistic Elements (fig. 6–21) are potted plug-in units whose inputs to the computer circuits are proportional to the ballistic constants of the ammunition which they represent.

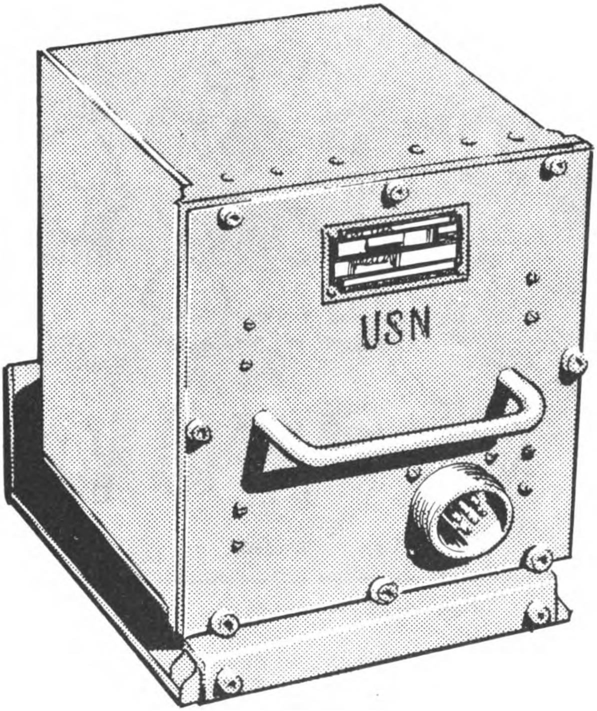


Figure 6–24.—Voltage Regulator Mk 14 Mod 0.

Air Flow Compensator Mk 1 Mod 0 (fig. 6–21) is a potted plug-in unit that contains the circuit elements required by the computer to account for any difference between the measured angle of attack and true angle of attack. Similar skid angle functions are also included. A screwdriver potentiometer adjustment, calibrated in mils, is provided in the angle of attack circuit to compensate for fixed errors in the angle of attack detector.

Airstream direction detector (fig. 6–27) is accurately designed to measure local airstream direction over a range of plus or minus 15 degrees. As indicated in the schematic diagram, figure 6–27, the detector tube has two symmetrical slots and is free for limited rotation of approximately 30 degrees around its axis. A separator inside the tube permits air to pass down each half of the tube and to flow from

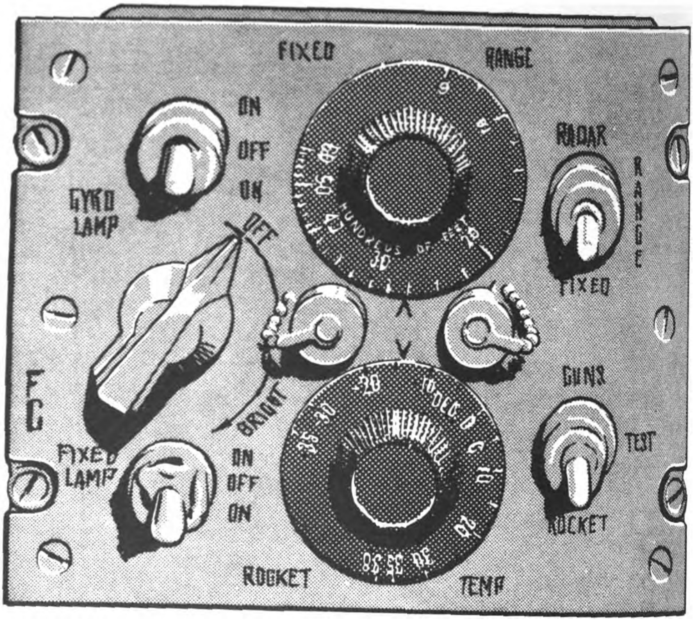


Figure 6–25.—Control Box Mk 35 Mod 1.

either slot to the corresponding orifice at the base of the slot. A paddle is connected to the tube by a pin and a slot linkage in the base of the device. Any misalignment of the detector head with respect to the local airstream produces a pressure differential at the slots. This causes the paddle to rotate, driving the detector tube in such a direction as to realign the plane of symmetry (a plane equally spaced between the

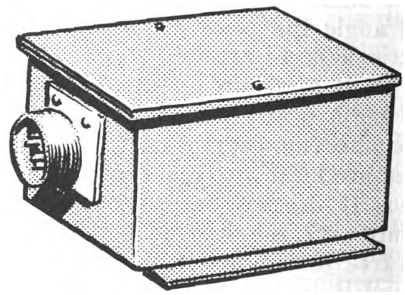


Figure 6–26.—Power Supply Mk 75 Mod 0.

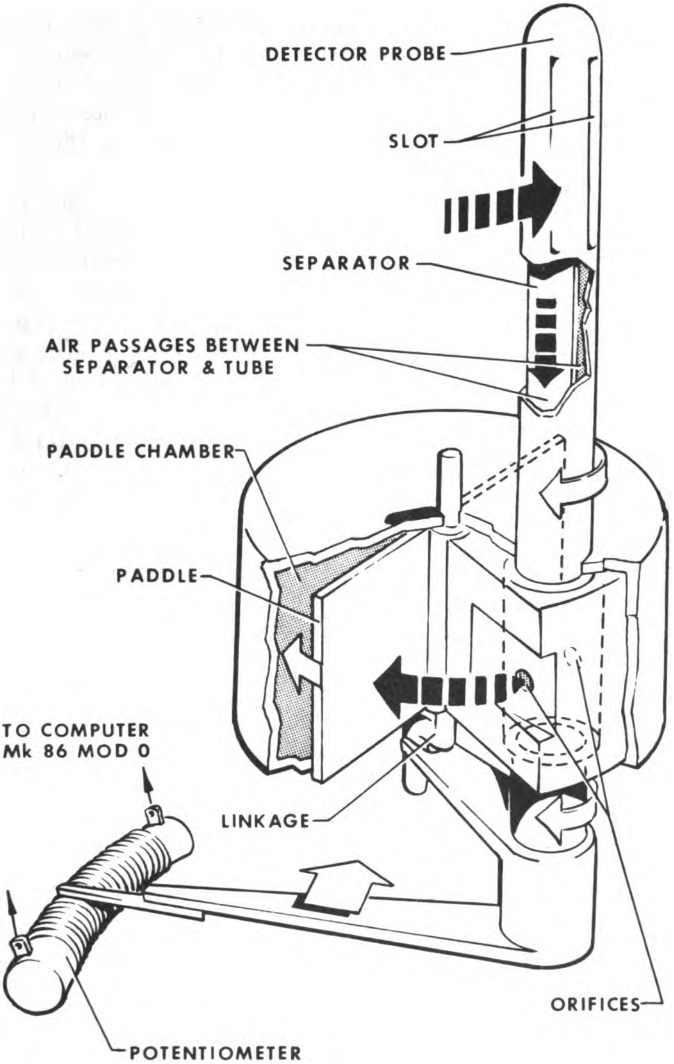


Figure 6–27.—Airstream direction detector.

two slots) of the slots with the local airstream direction. Rotation of the detector ceases when the differential pressure is reduced to zero. Thus, the angular position of the detector tube determines the local airstream direction, and a pickoff potentiometer provides the corresponding electrical signal. Two detectors are required, one for measurement of angle of attack, and another for measurement of the angle of skid. The external mounting positions of these detectors are determined by the type of airplane on which they are installed.

BORESIGHTING THE SIGHT UNIT MK 11 MOD 1.—This procedure should be accomplished after the initial installation of the equipment and at periodic intervals as required for maintenance purposes. The purpose of this procedure is to adjust the fixed reticle image and to align the center pip of the fixed reticle image to the fixed reference line (the gun line) of the aircraft. Align the fixed reference line of the aircraft on a target screen pattern having both a horizontal and a vertical reference line. Level the aircraft laterally. For detailed information on the location of the sight fittings, leveling lugs, alignment methods, and target screen patterns, refer to the Maintenance Instructions for the specific aircraft under consideration.

Illuminate the fixed reticle image by turning the fixed lamp switch to ON and by turning the bright-off knob clockwise. Operate the fixed reticle image selector knob on the instrument board to unmask the fixed reticle image. Observe the vertical alignment of the ladder markings of the fixed reticle image as compared to the vertical reference line on the screen target. If the image is not plumb, tilt the sight unit by turning the tilt boresight control on the instrument panel.

The boresight controls are detented to lock every 90 degrees of rotation. Each cable can be turned by inserting a screwdriver into one of the slots and pressing in until the detent is free. Turn each cable in 90 degree increments. Do not allow a cable to remain between detents.

Note the position of the center of the fixed reticle image relative to the boresight point on the screen target. When the center of the fixed reticle image is not aligned on the boresight point, the sight unit should be aligned by means of the elevation boresight control on the instrument panel and the azimuth adjustment screws on the sight unit. Turn the elevation boresight control to center the fixed reticle image vertically with the boresight point. Center the fixed reticle image laterally by loosening one azimuth adjustment screw while tightening the opposite screw. On completing this procedure, recheck as necessary to insure proper boresighting.

INSTALLATION.—Aircraft Fire Control System Mk 16 Mod 2 is designed for installation and use in day fighter aircraft. The system is so diversified that no set installation procedure can be given. The build-up is designed for use in different types of aircraft and for use with different types of guns and rockets.

Only generalized instructions may be given here. The Mk 86 Mod 0 computer does not contain any pilot operated controls and may be mounted at any location in the aircraft where it is accessible for preflight adjustment and maintenance. The sight unit is installed in the cockpit at eye level position and it is boresighted so that the fixed reticle image is aligned with the gun datum line. The Computer Mk 87 Mod 0 is shock mounted and should be in a position close enough to the radar components for adjustment and repair. The Mk 75 Mod 0 power supply should be mounted as close to the computer as possible for convenience of maintenance.

MAINTENANCE.—The maintenance of the Fire Control System Mk 16 Mod 2 consists of preflight inspections and periodic checks.

The computer and all the components should be checked to see that the correct gear is installed for the operation to which the aircraft is assigned. In performing this check, notice the condition of the units and the connecting cables and their mounts.

The Mk 11 Mod 1 sight head will have two types of spare bulbs for the replacement of the fixed and gyroscope image illumination. Make sure they are properly labeled for quick reference when needed. The sight must be kept clean. No bench maintenance should be performed on the sight unit that requires opening the body or removing the cover plates, thus breaking the airtight seal. Failure of the Gyroscope Mk 35 Mod 1, the desiccator, or any of the internal optical parts (except the reticle lamps and the reflector plate) requires that the sight unit be sent to an overhaul activity for repair.

To check the system thoroughly use the Test Unit Mk 49 Mod 0 (fig. 6–28) which is provided for use specifically with this fire control system. The test unit is used to check the

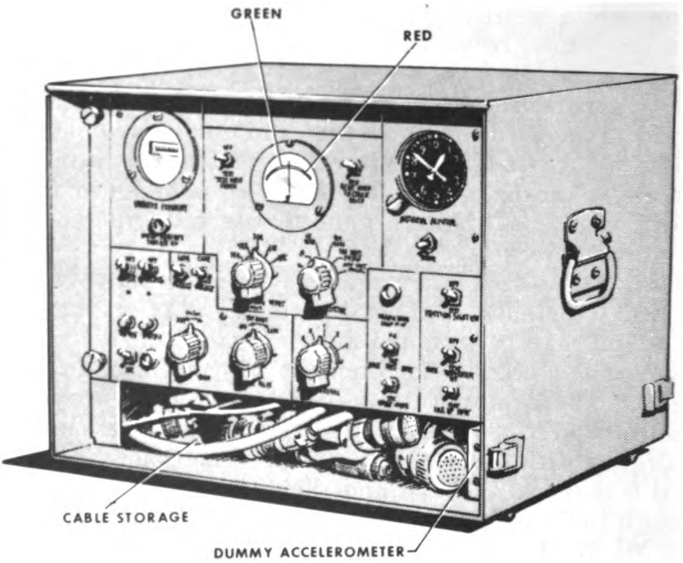


Figure 6–28.—Test Unit Mk 49 Mod 0.

computer individually, and with the rest of the gear when used in the system with the test unit connected. The test unit will isolate trouble to a particular circuit by following the directions in the service manual of the test unit.

The test unit operates by supplying known inputs to the Computer Mk 86. These inputs include range, range rate, air pressure (altitude), acceleration, sight unit dome temperature, rocket propellant temperature, attack angle, and skid angle. These known inputs produce predictable output currents which flow through metering resistors. The resultant voltage across one of these resistors is compared by means of a zero-center meter to a reference voltage which represents the correct solution to the fire control problem. If the computer is operating properly, the two voltages will not be the same and the meter deflection will be large.

In addition to testing the output currents, the Mk 49 Mod 0 test unit will check amplitudes and phase angles of voltages at certain points in the computer by a similar method. These voltage checks permit most troubles to be isolated to the plug-in units in which they occur.

The test unit also contains circuits for performing special tests on Sight Unit Mk 11 or Mk 8, Computer Mk 87, and Computer Mk 86.

When the trouble has been isolated to a circuit that is possible to repair, use the proper test gear and repair as is indicated by conditions. This maintenance discussion is by no means complete and is written to give only a general idea of the gear.

QUIZ

1. The Mk 20 illuminated sight is designed for use in
    - a. torpedo bombers
    - b. heavy bombers
    - c. dive bombers
    - d. night fighters
2. To remove internal fogging in a Mk 20 illuminated sight the maximum pressure of dry nitrogen that should be used is
    - a. 5 pounds
    - b. 10 pounds
    - c. 4 pounds
    - d. 3 pounds
3. In the Illuminated Sights Mk 8 and Mk 20, the zero sight line is boresighted to/with the datum line
    - a. parallel
    - b. converging
    - c. superimposed
    - d. at a tangent
4. When boresighting the Illuminated Sight Mk 8 or Mk 20, what adjustment is made first?
    - a. Parallax
    - b. Azimuth
    - c. Elevation
    - d. None of the above
5. In the Mk 8 illuminated sight, parallax is caused by
    - a. relative motion between target and reticle image
    - b. sight being out of collimation
    - c. being out of boresighting adjustment
    - d. internal fogging
6. The day reticle of the Mk 8 illuminated sight contains the following mil value rings:
    - a. 50 and 100
    - b. 90, 135, 225 and 270
    - c. all of the above
    - d. none of the above

7. The illuminated gunsight used in conjunction with the Mk 23 bombsight is the
   a. Mk 8 Mod 8
   b. Mk 11 Mod 1
   c. Mk 9 and Mods
   d. Mk 20 Mod 0

8. The Illuminated Gunsight Mk 9 was originally designed for use in
   a. fixed gunnery only
   b. fixed gunnery and rocket firing
   c. fixed gunnery, rocket firing, and low altitude bombing
   d. flexible gunnery

9. When using the Mk 18 gunsight, the gunner must accurately preset the correct target wingspan, his own altitude, and the
   a. ballistic factor
   b. range to target
   c. indicated airspeed
   d. azimuth and elevation deflections

10. The gyroscopic reticle image is composed of
    a. six diamond-shaped dots and a cross
    b. a circle and a round center dot
    c. six diamond-shaped dots and a round center dot
    d. a circle and a cross

11. The gryoscopic reticle is formed by two disks, one is called the range disk, the other is called the
    a. fixed disk
    b. span disk
    c. slotted disk
    d. spiral disk

12. The gyroscope unit contains how many mirrors?
    a. One
    b. Two
    c. Three
    d. Four

13. When using the Mk 18 gunsight, the imaginary circle formed by the six diamond-shaped dots may be expanded or contracted by how many methods?
    a. One
    b. Two
    c. Three
    d. Four

14. What componet of the reticle images may be masked out?
    a. Circle
    b. Cross
    c. Six diamond-shaped dots
    d. Round center dot

15. The mirrors used in the Mk 18 gunsight are aluminized on their front surfaces to prevent what kind of images?
    a. Ghost
    b. Reverse
    c. Single
    d. Double

16. How many sets of coils are used to control the action of the gyroscope?
    a. Two
    b. Four
    c. Six
    d. Eight

17. How are the azimuth coils wired?
    a. Series
    b. Parallel
    c. Series opposition
    d. Parallel opposition

18. Gravity coil current is maximum at what degree of gun elevation?
    a. 0
    b. 45
    c. 90
    d. 135

19. What color indicates a dry condition of the silica gel used with the Mk 18 gunsight?
    a. Amber
    b. Pink
    c. White
    d. Blue

20. As altitude increases, windage allowances
    a. increase
    b. decrease
    c. stay the same
    d. equal 0.3 times the square root of the altitude in feet

21. If the gunner were to increase his airspeed setting, current in the gravity coils would
    a. increase
    b. decrease
    c. stay the same
    d. vary inversely proportional to the altitude

22. The Mk 18 gunsight will automatically compute for bullet trail which is the same as
    a. target deflection
    b. operator's deflection
    c. gravity drop
    d. windage

23. The diameter of the center dot of the gyroscopic reticle image is approximately
   a. 0.85 mils
   b. 1 mil
   c. 1.7 mils
   d. 2 mils

24. In order to align the fixed mirror of the Mk 18 gunsight, what unit or part must be removed?
   a. Masking lever
   b. Motor housing
   c. Reflector plate
   d. Silica gel cell

25. After the initial warmup period, the dots of the gyroscopic reticle image appear round and enlarged. What action should be taken?
   a. Oil the Hooke's joint
   b. Change reticle disks
   c. Check voltage regulator
   d. Send light to overhaul

CHAPTER 7

BOMBSIGHTS

BOMBSIGHT MK 23 AND MODS

Effective horizontal bombing requires the accurate solution to the problem of releasing a bomb from an aircraft in level flight at constant speed in order that the bomb may strike the ground at a predetermined point. The solution to such a problem is highly complicated. Therefore, it is necessary to employ various aids in order to solve the problems quickly and accurately, with as little introduced human error as possible.

DESCRIPTION.—Bombsights are divided into two broad classes: HIGH LEVEL and LOW LEVEL bombsights. The Mk 23 bombsight and its modifications were designed for low level bombing. In order to solve the problems for high level bombing, the bombsight must solve for altitude, groundspeed, trail, cross trail, and the type of bomb being used. However, in using the low level Mk 23 bombsight, bombing may be accurately accomplished by solving ONLY for altitude, ground speed, and the type of bomb being used. This means that the low level bombsight is considerably less complicated than the high level sight.

The low level sights are further divided into two classes: the ANGLE OF DEPRESSION SIGHT and the ANGULAR RATE SIGHT. The Mk 23 bombsight is of the latter type. In the angle of depression sight, the altitude, groundspeed, and type of bomb being used (ballistic coefficient) are set into the sight. These factors cause a depression of the line of sight with relation to the flight path. The operator looks through the sight and manually (or electrically) releases the bomb stores when the line of sight crosses the target. In the angular rate type of sight, the same data is set into the sight. The operator rotates the tracking head to hold the line of sight on the target while the bombing run is being made. The mechanisms of the sight measure the ANGULAR TRACKING RATE which corresponds to the proper release point. The bomb stores will then be released at the proper instant automatically.

The angular rate type bombsight has proved to be much more accurate than the angle of depression type sight. In a theoretical case in which an operator misjudges the altitude or groundspeed by the same amount in using both of these types of sights under similar conditions, the angular rate sight will give a considerably smaller error at the target than the angle of depression sight. Therefore, the angular rate sight (Mk 23) is much more desirable.

The Mk 23 bombsight was designed specifically for bombing in connection with antisubmarine warfare. It will compute the correct time of release for low level bombing attacks. These attacks are made between 50 and 500 feet in altitude, and at speeds from 120 to 300 knots. The pilot flies a collision course with the target in making a low level attack. Thus, the bombsight makes no computation for azimuth. Since trail and cross trail are negligible in bombing runs made at or below 500 feet, the Mk 23 sight has to make computations for the problem of range only. The Mk 23 sight may be used at altitudes of over 500 feet provided it is modified. However, much of its accuracy is lost when used in this manner.

A study of figure 7–1 will show how the Mk 23 bombsight is used in making low level attacks. The line AB represents the flight path over the target, T. The bomber is flying at altitude, H. The line, PT, from the bomber, P, to the target, T, is called the LINE OF SIGHT. The angle a is the angle between the flight path and the line of sight. This is called the ANGLE OF DEPRESSION. It will be seen that the angle a will be small when the bomber is at some distance from the target, and will increase until it reaches 90 degrees as the bomber passes directly over the target. Consider the rate at which the line of sight, PT, must be rotated by the operator in order to hold it on the target as the bomber closes the range. It will be noted that the rate of rotation will be very slow at first and will rapidly increase as the bomber nears the target. At some point along the line AB, the

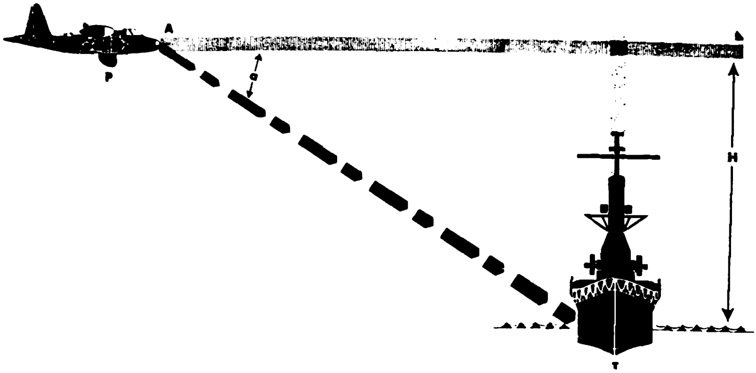


Figure 7–1.—Employment of the Mk 23 bombsight in low level attack.

stores must be dropped in order for them to hit the target. The location of this point depends upon the altitude, the groundspeed of the bomber, and the ballistic coefficient of the bomb being used.

The Mk 23 bombsight consists of four major components: the SIGHT UNIT, the TRACKING UNIT OR HEAD, the CONTROL BOX, and the MOTOR ALTERNATOR OR INVERTER. The sight unit is mounted on the top of the tracking head in Mods 0–4, 7, and 9, and is eliminated on Mods 5, 6, and 10. Its function is to establish the line of sight. The tracking unit houses all the computing mechanisms of the sight, and establishes the dropping angle during tracking. The control box is located close to the sight unit and tracking head in the early modifications. (See fig. 7–2.) The Mk 23 Mod 10 sight has no optical sight on top of the tracking head. The Mod 10 is mounted within the forward gun turret. The turret gunsight and the motion in elevation of the turret are used to track the target. The function of the control box is to act as a junction box for all electrical and vacuum lines, and additionally as a stand for the Mod 10 tracking head. The motor alternator is located close to the other components. Its function is to furnish alternating current to the gyroscope in the tracking head. UNLESS OTHERWISE NOTED, THE FOLLOWING DESCRIPTIONS APPLY TO THE MK 23 MODS 0–4 SIGHTS.

SIGHT UNIT.—The sight unit consists of an illuminated gunsight (Mk 9), which has been adapted to use with the Mk 23 bombsight. It is mounted on the top of the tracking head. The illuminated reticle of this optical sight establishes the line of sight. The intensity of the light in the sight unit is varied by the rheostat on the right rear side of the tracking head.

The Mk 9 illuminated gunsight has been discussed in chapter 6 of this book. The basic Mk 9 gunsight had inadequate provisions for viewing the nomograph of the Mk 23 and Mods bombsight. Later modifications of the Mk 9 sight, used with the Mk 23 and Mods bombsight, incorporate an additional lens system in the upper part of the hood assembly for viewing the nomograph and its indices. This system greatly reduced parallax. Additional maintenance of the Mk 9 sight involves checking these collimated lenses for adjustment and security.

A sighting bracket with associated lens with which to view the nomograph is installed on the Mk 23 Mods 5, 6, and 10. This assembly replaces the Mk 9 gunsight. View-

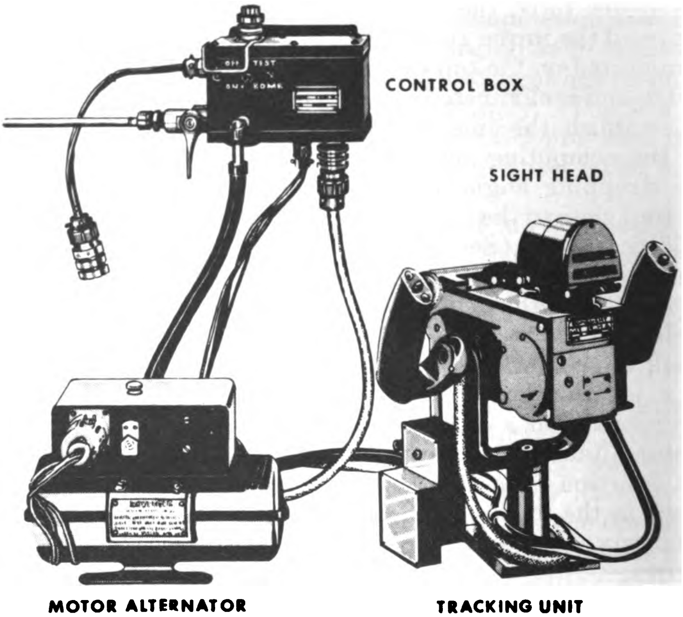


Figure 7–2.—The Mk 23 Mod 0 bombsight.

ing the target with the Mods 5 and 6 is accomplished through a periscope. The Mod 10, being installed in a turret, makes use of the turret gunsight for viewing the target.

TRACKING HEAD.—The tracking head of the Mk 23 bombsight consists of a housing which contains the optical and mechanical components of the equipment. A stand with attached yoke supported the tracking head of the earlier modifications. (See fig. 7–2.) The yoke supports the tracking unit by its two trunnions and bearings. All electrical connections and the vacuum source are supplied to the tracking unit through these hollow trunnions; the vacuum pressure through the right trunnion, and the electrical supply through the left trunnion.

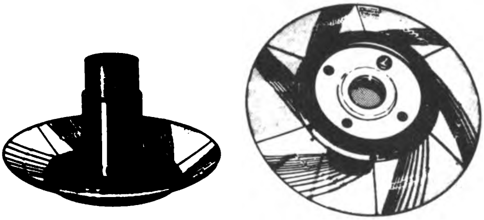


Figure 7–3.—Nomographs for Mk 23 bombsight.

The NOMOGRAPHS are contained in the rear section of the tracking head. Briefly, a nomogram is an alignment chart or a graph that enables one, by the aid of a straightedge, to read off the value of a dependent variable when the value of the independent variable is given. In the case of the Mk 23 bombsight, the nomograph gives a graphic representation of numerical relations by means of the index marks on the clear film disk. The nomographs and their associated index marks are viewed through a window on top of the tracking head which is located close to the Mk 9 illuminated gunsight in the Mods 0–2. In the Mods 3 and 4 the operator may see both the reticle of the gunsight and the nomograph without shifting his head appreciably. The nomograph is illuminated by a small lamp which is wired in parallel with the Mk 9 sight reticle lamp. Its intensity is varied simultaneously with that of the reticle lamp. (See fig. 7–3.)

The proper height and speed settings for a bombing run are set into the Mk 23 bombsight by movement of the height adjusting knob on the upper front corner of the housing, and by rotating the nomograph by means of the nomograph adjusting knob (groundspeed knob) on the wall of the housing. Setting the nomograph actuates a gear train which puts a tension on the calibrated spring. This spring is attached to the gyroscope. This action applies a known torque to the gyroscope in direct proportion to the required angular velocity of the tracking unit to assure a hit with the bomb stores.

The nomographs are so designed that their indices (index marks) make an accurate allowance for the difference in location of the bombsight position and the position of the bomb stores. The proper set of indices has to be selected for this difference in location for each type of aircraft. Each type of aircraft will have a different set of values, both for vertical and horizontal differences in location, because in each type the bombsight is located in a different position with respect to the bomb stores. This difference in vertical and horizontal displacement of the bombsight from the bomb stores is known as VERTICAL AND HORIZONTAL PARALLAX.

The design of all nomographs is based on an intended point of impact of the first bomb 35 feet short of the target, plus one-half of the STICK LENGTH. STICK LENGTH here refers to the distance between the point of impact of the first bomb and the point of impact of the last bomb when dropped in train using an intervalometer.

To select the different stick lengths, the index knob is rotated after first pulling it out against the spring tension of the retaining spring. When the desired stick length is obtained, the index knob is released and turned slightly. The nomograph will slide into place.

To change a nomograph disk it is necessary to loosen the four nomograph cover plate screws, and remove the cover. Next, the terminal block is lowered by removing the two retaining screws. The indexing knob retaining screw is removed along with the indexing shaft retaining spring. With an orangewood stick or slip of cardboard, depress the upper portion of the nomograph disk slightly to clear the tracking housing. The nomagraph is then free to come out. Pull it off the indexing shaft. Reverse the above procedure to replace the nomograph.

The nomograph disk is made of clear film. It is divided into six sections called NOMOGRAPHS. These nomographs represent stick lengths and are numbered 0, 70, 140, 210, 280, and 350. Each of these stick lengths has ten graphic black lines which are called ESTIMATED GROUNDSPEED LINES. (See fig. 7–4.) The information given in the identification sector of the nomograph disk contains the Mk and Mod of the bombsight, the time constant (described later), aircraft type, bomb type, vertical and horizontal parallax, bomb rack delay, altitude, closing speed, and the stick length. All of these factors enter into the computations in using the Mk 23 bombsight.

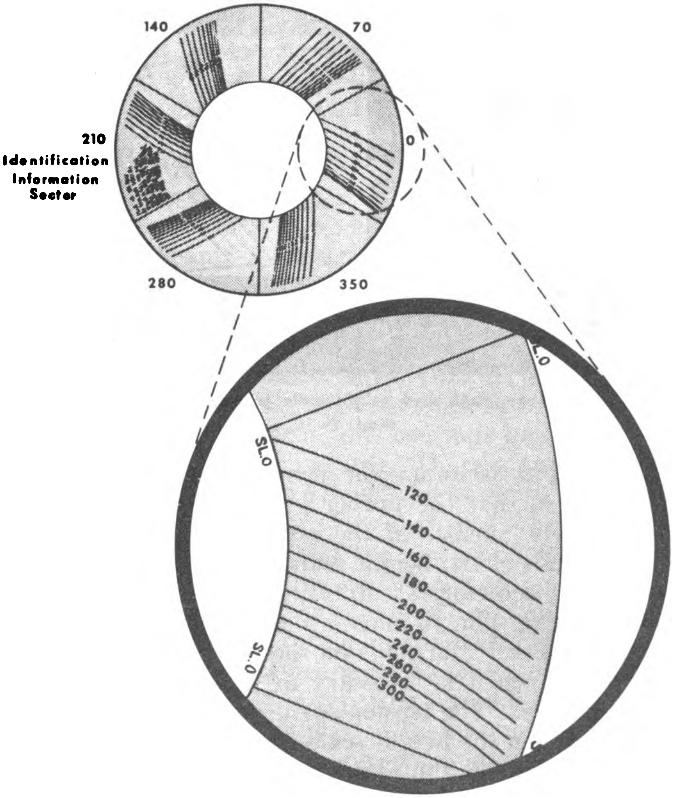


Figure 7–4.—Nomograph disk schematic.

To determine the distance the first bomb of the train drop, or stick, would fall short of the target, the stick length in use is divided by 2 and the results of this division added to 35 feet. Take the 210 stick length as an example: $\frac{SL}{2}$, or $\frac{210}{2}+35=105+35$, or 140 feet. This indicates that in using the 210 stick length, the first bomb in the stick will fall 140 feet short of the target. The zero stick length (enlarged in fig. 7–4) will cause the first bomb in the stick to drop 35 feet short of the target.

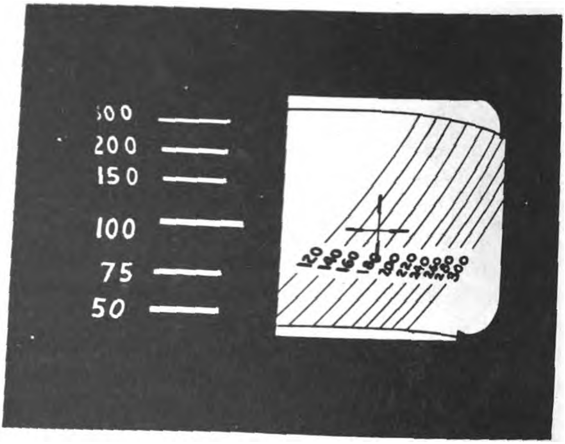


Figure 7–5.—Nomograph and height scale pattern on Bombsight Mk 23 Mods 0–10.

The ALTITUDE ASSEMBLY functions to permit setting up of a reference so that the proper groundspeed may be used. This assembly consists of the altitude knob (height scale knob), altitude shaft, height scale film, tension spring, and other holding accessories. Rotating the altitude knob causes the height scale film to move up and down in front of the nomograph disk. Markings on the left side of the film indicate how much it is necessary to rotate the knob for the proper altitude. The tension spring prevents the film from kinking. When the height scale film is moved up or down, a fixed cross on the film also moves up or down. (See fig. 7–5.)

The GROUNDSPEED ASSEMBLY functions to permit setting in of the proper groundspeed by the proportional rotation of the indexing shaft, and applying a fixed amount of tension to the calibrated spring. This assembly consists of the wormshaft knob (groundspeed knob), the wormshaft, worm gear, spring guide, calibrated spring follower, and assorted brackets and accessories. (See fig. 7–6.)

Rotation of the wormshaft knob causes rotation of the wormshaft. The calibrated spring follower moves back and forth on the wormshaft because it is held in place by the spring guide. The larger worm gear on the wormshaft rotates the indexing shaft which in turn causes the nomograph disk to rotate a proportional amount. To set in the correct groundspeed, the desired groundspeed line on the nomograph is made to intersect the center of the fixed cross.

The function of the CALIBRATED SPRING is to apply a measured amount of tension to the gyroscope. One end of the calibrated spring is attached to the calibrated spring follower, and the other is attached to the gyroscope. Turning the groundspeed knob causes tension to increase or decrease between the gyroscope and the spring follower. (See fig. 7–6.)

The function of the GYROSCOPE is to act as a computing and calculating mechanism between the calibrated spring and the angular tracking velocity. THIS GYROSCOPE IS THE ANGULAR VELOCITY MEASURING DEVICE. The gyroscope is a synchronous, induction type electric motor. It is powered by a regulated 115-volt, 3-phase, 400-cycle alternating current. The speed of the motor is 12,000 revolutions per minute. It is held in place by gimbals and bearings and operates in one plane only, the tracking plane. There is no necessity for mounting the gyroscope on a double set of gimbals as it needs motion only in the tracking plane.

The spin (spin velocity) of the gyroscope is in a proper direction to the tracking angular velocity to cause the gyroscope to precess about its only axis of rotation. This precessing motion is limited by the gimbal bearings. The precessing torque of the gyroscope is in opposition to the calibrated spring action. This opposing action is brought about by the stretching of the calibrated spring during the indexing of the nomograph. The gyroscope system of the sight applies a torque to the vacuum cup which is equal to the

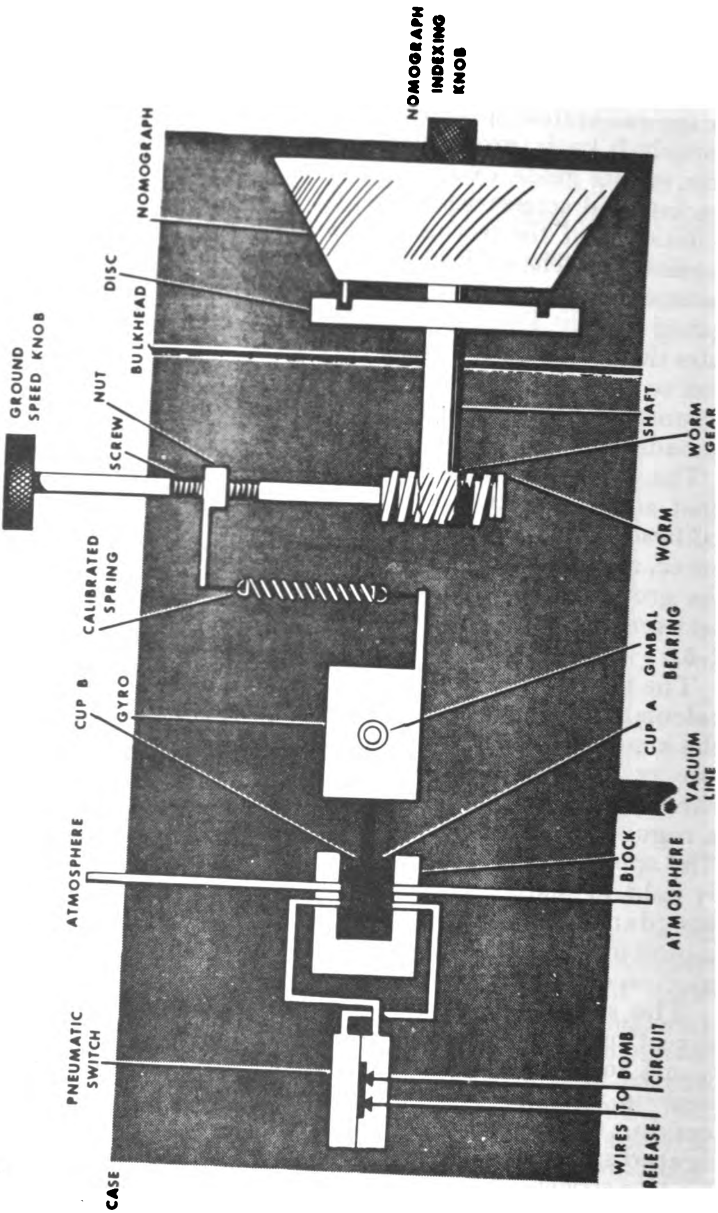


Figure 7—6.—Schematic diagram of Bombsight Mk 23 Mods 0—10.

difference between the calibrated spring tension and the precession torque. When the precession torque (generated by the tracking operation of the sight) indicates the angular velocity required for a hit, the calibrated spring torque is balanced out, or zero.

The point of balance between the calibrated spring tension and the precession torque is measured pneumatically (vacuum against atmospheric pressure) within the sealed bombsight housing. It is absolutely necessary to keep the 400-cycle current within 0.5 percent of its rated figure since the precession force of the gyroscope is directly proportional to the gyroscopic spin velocity, or 12,000 revolutions per minute.

The PNEUMATIC CUP AND PNEUMATIC BLOCK ASSEMBLY function by transmitting mechanical impulses received from the gyroscope and by relaying pneumatic ones to the pneumatic switch. (See fig. 7–6.) The pneumatic block assembly is mounted on the gyroscope gimbal frame and is movable about the gimbal axis within the limits of the movement of the gyroscope. The pneumatic cup assembly is mounted on an arm which is 90 degrees to the cylinder assembly. The distance along this arm, from the gimbal axis to the axis of the cup assembly cylinder, forms the lever arm of a force. This force measures the difference between the calibrated spring force (as applied by the operation of indexing the nomograph) and the precessional torque force of the gyroscope, which is caused by the angular velocity of the tracking unit during tracking.

The pneumatic cup assembly is located within the rectangular slot of the pneumatic block assembly. The motion of the pneumatic cup assembly is limited by the sides of the pneumatic block slot. Air under atmospheric pressure enters the pneumatic cup assembly through a set of fixed orifices (holes) and is admitted to the spaces under the pneumatic cups. This air escapes through the variable openings between the knife edges of the pneumatic cups and the pneumatic block slot. It is drawn into the housing of the bombsight because this compartment is under a partial vacuum (4 inches of mercury) from the vacuum pump of the aircraft's engine. The pressure differential is therefore the cause of this movement of the atmospheric air. The pneumatic switch, which is normally closed, is attached to the pneumatic cup block. This switch compares the pressure existing under the pneumatic cups. When the pressure under these cups is equalized, the pressure switch opens the circuit. This opening of the pneumatic switch actuates the circuits to release the bomb stores through a set of relays; a single and a double relay.

Inside the air lines between the pneumatic switch and the pneumatic block assembly, there are two restrictions of fixed size. These restrictions cause a resistance to the atmospheric air and the vacuum as they pass through the lines. The volume of the air contained in the pressure switch and the resistance in the lines together form what might be called a FILTER OR BUFFER to smooth out the pneumatic signals generated by the movements of the pneumatic cups. During this process of smoothing or dampening out the signals, a delay of 0.8 second is experienced. Therefore, there is a set delay between the time that the angular velocity indica-

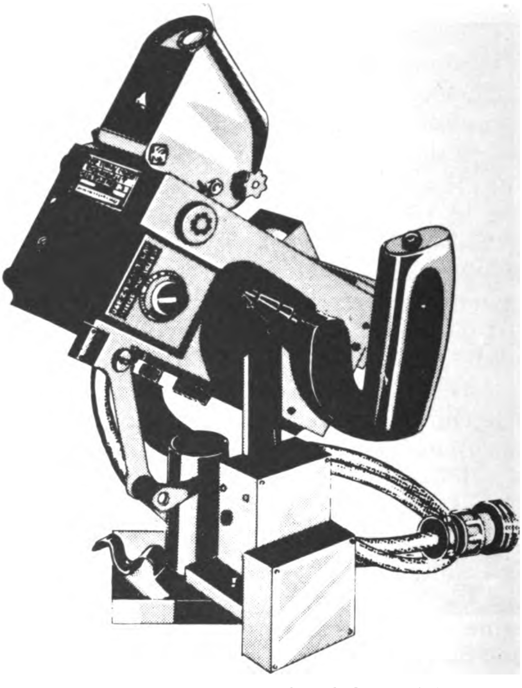


Figure 7–7.—Bombsight Mk 23 Mod 3.

tion of the correct release point is obtained and the time the signal reaches the pressure switch. This is known as the TIME CONSTANT and is a standard part of the information shown on the nomograph indentification plate. The nomographs are designed and computed to take care of this delay as well as the normal measurable delays experienced in the electrical and mechanical bomb stores releasing process.

Handle grips are mounted on the ends of both trunnions of all modifications of the Mk 23 bombsight except Mods 5, 6, and 10. (See fig. 7–7.) Grips on these modifications have either been relocated or eliminated. The handle grips are used essentially to rotate the tracking unit. However, the handle grip on the left side of the tracking head carries a microswitch used to energize the microphone circuit, and the grip on the right side has in it a microswitch for arming the bomb stores. Since both hands of the bombsight operator are busy while tracking a target, a throat microphone has to be used instead of the regular hand-held type. The arming switch is a safety device in that the operator has to depress this switch prior to and during the instant the sight reaches the dropping angle in order for the bombs to be released. A ten-wire electric cable enters the tracking unit through the same trunnion on the right side of the tracking unit to which the right handle grip is attached. A vacuum line enters the housing of the tracking unit through the trunnion on the left side.

On the Mk 23 Mods 0–3 an inertia tracking aid is attached to the left side of the mounting yoke. It is connected to the tracking head through suitable linkage. It consists of a friction clutch, a flywheel, and gearing. Its function is to aid the operator in tracking the target in rough air. In the Mod 4 a hydraulic dashpot is connected between the air inlet shaft and the mounting yoke to act as an aid in tracking the target.

CONTROL BOX.—The component parts of the control box for the Mk 23 bombsight consists of a vacuum regulator and shutoff valve, single and double relays, electrical switches, and a terminal block. The VACUUM REGULATOR is connected to the vacuum pump of the aircraft. Its function is to maintain a constant source of vacuum to the tracking head. This vacuum is adjusted at four inches of mercury. The regulated vacuum source is connected to the tracking head by a flexible line through the tracking head trunnion, as previously described. If the vacuum becomes excessive, a safety feature in the form of a diaphragm allows the outside air to enter the vacuum line. The vacuum source is controlled by the shutoff valve.

The SINGLE RELAY acts as a safety for the double relay. The DOUBLE RELAY actually closes the circuit to the bomb store releasing device, or to the test circuit. When the pneumatic switch contacts open in the tracking head (due to pressure equalization), the single relay is actuated. The single relay then actuates the double relay IF THE ARMING SWITCH IS CLOSED. Should the operator fail to close the arming switch on the right handle grip, the double relay in the control box will not be actuated. Thus, the bomb stores would not be released.

The MASTER SWITCH controls all power to the bombsight. It is a single-throw, double-pole switch, and controls the input direct-current power from the aircraft.

The TEST AND BOMB SWITCH is selective. It determines which of these two circuits is to be energized.

The TERMINAL BLOCK acts as a binding post for all interconnecting leads to the control box. The ten-wire cable to the tracking head terminates at the control box in a ten-terminal AN connector. Wires from the control box are fed through a four-terminal AN connector to the terminal block.

MOTOR ALTERNATOR.—The motor alternator (inverter) unit receives the direct current from the aircraft's generator and converts it into 400-cycle, 3-phase, 115-volt alternating current. This converted current is regulated by a centrifugal governor to maintain the current within 0.5 percent of the rated value. This is necessary because the precessional force of the gyroscope in the tracking head is directly proportional to the spin velocity (r. p. m.) of the gyroscope. The motor alternator turns at 12,000 revolutions per minute, and is fan cooled.

OPERATION.—The Mk 23 bombsight master switch is turned on to permit the gyroscope to reach its proper operating speed. This should be done at least 15 minutes before entering the bombing run. The master switch should be in the ON position and the gyroscope running when entering the area in which targets may be sighted. As soon as the gyroscope is up to operating speed, turn the vacuum source petcock to the ON position. Set the test selector switch to TEST. Press the arming switch and track an imaginary target. Lighting of the test lamp indicates that all circuits of the bombsight are in operating order. The test described above should be repeated two or three times during the flight prior to actual use of the sight to release the stores. Accuracy is improved by occasional operation of the sight. After the test is completed, turn off the vacuum petcock to prevent drawing dust into the tracking head.

The rheostat of the Mk 9 illuminated sight is adjusted so that the reticle is visible against its background and the nomograph is properly illuminated. The correct nomograph for the desired stick length is selected, and the height index is set for the altitude at which the bombing run is to be conducted. The velocity curve on the nomograph is selected which is nearest to that of the aircraft's groundspeed, and it is matched with the height index spot. When the test selector switch is in the TEST position, it forms a positive safety device to prevent premature release of the bomb stores if the arming switch and tracking head are actuated accidently.

As soon as the target is sighted, turn the vacuum petcock to the ON position. Place the test selector switch in the BOMB position. Check altitude, speed, and stick length settings. At the beginning of the bombing run, the reticle pip is placed on the target and tracking is begun. When smooth tracking is established, the arming switch (located on the right handle grip) is depressed. This switch is held in the depressed position until the stores are released. Releasing of the stores will occur automatically at the instant the proper rate is reached. At the end of the bombing run, turn off the vacuum petcock.

Modifications to the Mk 23 bombsight.—There are numerous modifications to the Mk 23 bombsight. Mods 1, 2, 3, 4, and 5 are all identical to the Mod 0 except for changes in the tracking unit. The Mod 3 incorporates the same changes as the Mod 2 except that the lens system for viewing the nomograph is redesigned. This redesigning places a lens in the upper part of the hood of the Mk 9 illuminated gunsight, and locates a plain glass window in the front position of the tracking head. This change provides a collimated (parallel light) system and also reduces the parallax found in the Mk 23 Mod 0 sight. The Mk 23 Mod 5 sight is mounted on an inverted yoke, and connected by a rod to the periscope of the aircraft. On the Mods 0–2 an inertia tracking aid is mounted on the left side of the yoke and the Mod 3 tracking aid is mounted on the right. These aids smooth out the tracking in rough air. The Mod 4 has a hydraulic dashpot attached to the right trunnion near the vacuum inlet. This also is an aid in smoothing out the tracking process.

The Mk 23 Mod 6 bombsight is used in ASW aircraft in which direct view sighting is not possible. (See fig. 7–8.) This bombsight is essentially the same as the Mk 23 Mod 5 with the exception of the mounting arrangement. The sight unit is mounted on a yoke which is in turn mounted to a pad on top of the Mk 41 Mod 1 periscope. Being so mounted, the sight follows the same vertical plane as the line of sight of the periscope. A pair of levers (arms) and an adjustable link connect the bombsight shaft to the periscope shaft so that any rotation of the periscope shaft is transmitted to the bombsight. The distance between the lines of sight of the bombsight and the periscope in the vertical plane is not critical. It is only necessary that the bombsight have unrestricted movement through the full range of the periscope's elevation and depression. The bombardier operates this system in the same manner as the other modifications except that he sights the target through the eyepiece of the periscope instead of the bombsight. The linkage (necessary due to relocation of the handle grips) between the bombsight and the periscope is adjusted to permit alignment of the lines of sight. The link is adjusted until the center lines through the holes in the upper and lower levers (arms) are parallel to one another within one degree to the center lines of the holes. The top and one side of the bombsight case should be parallel within one degree to the periscope line of sight for any angle of depression.

The Mk 23 Mod 7 bombsight is practically the same as the Mk 23 Mod 4 sight, but has an added hydraulic actuating system installed to control the movements of a searchlight (Type L–11). (See fig. 7–9.) A modified handle grip provides an addition switch, and elevation and azimuth scales

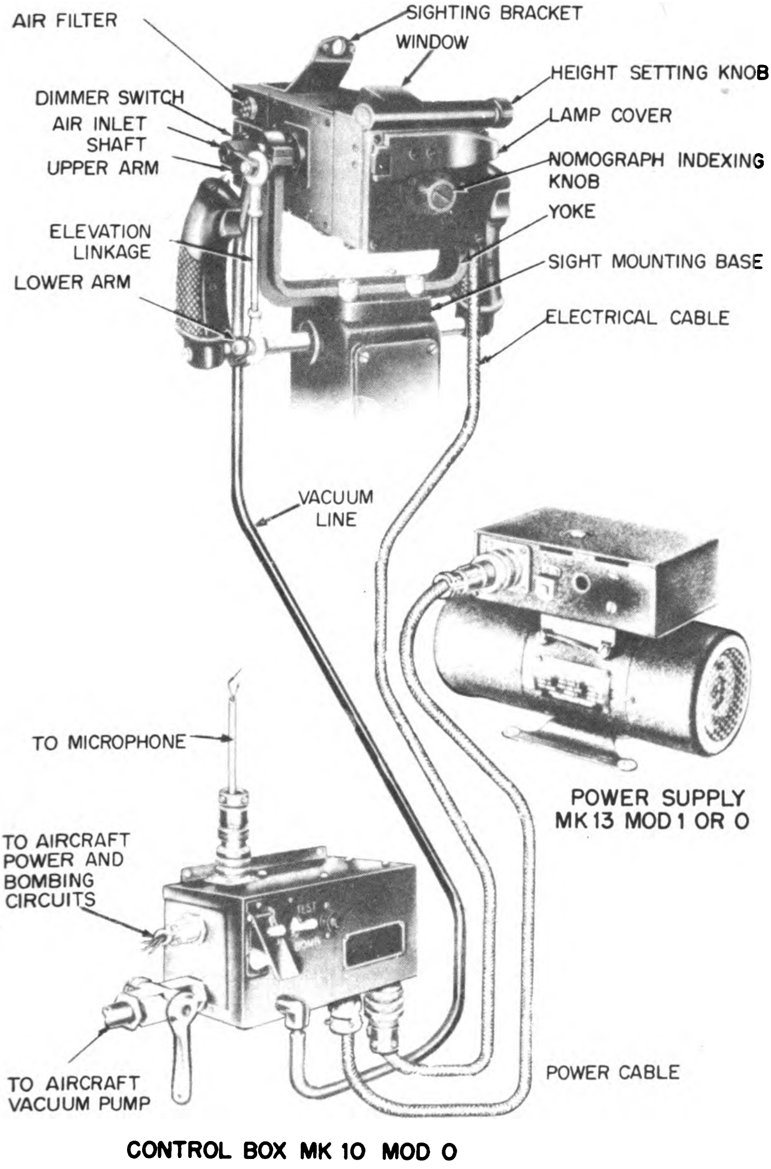


Figure 7–8.—Bombsight Mk 23 Mod 6.

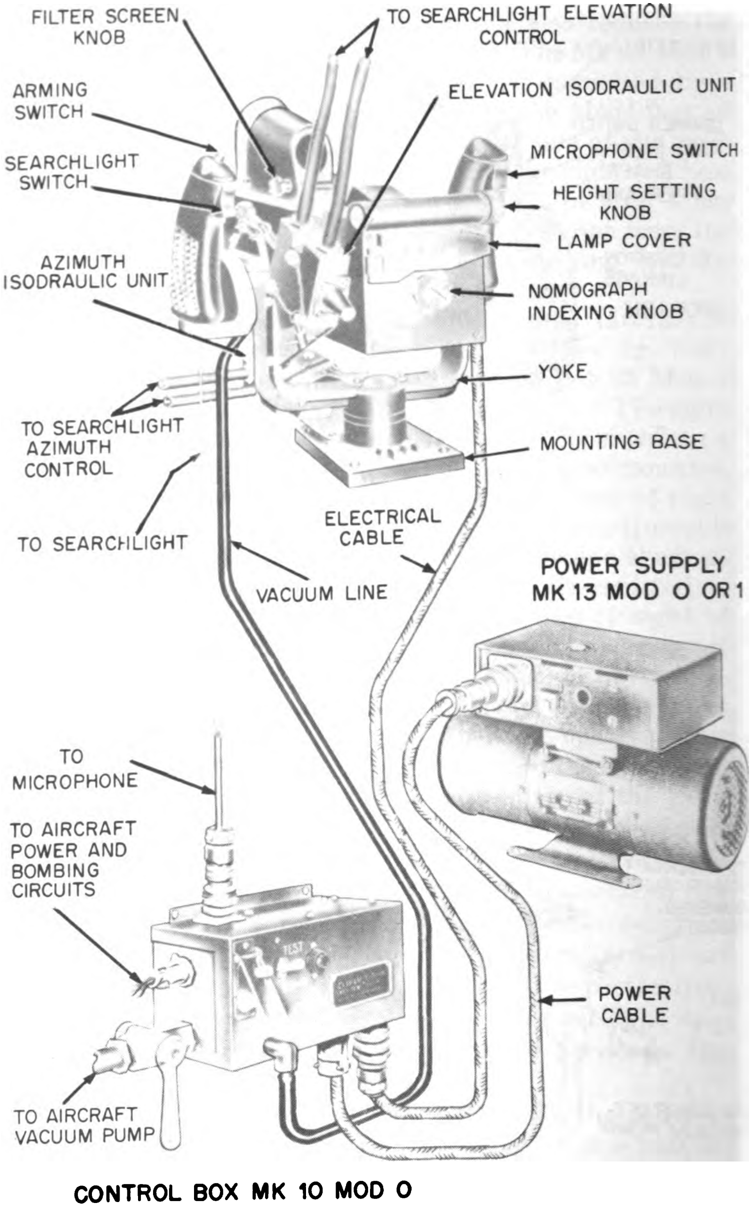


Figure 7–9.—Bombsight Mk 23 Mod 7.

have been installed. The sight is mounted within a yoke which is pivoted at the base in order to be rotated both in azimuth and elevation. Two separate "isodraulic" systems transmit motion of the bombsight to the searchlight which illuminates the target. Each "isodraulic" system is a standard remote control hydraulic system. It consists of a pair of hydraulic cylinders connected together by tubing so that any movement applied to one piston forces liquid through the tubes to the other cylinder, causing its piston to move in unison with the first piston. In each of these systems a master cylinder controls the slave cylinder, thus causing the movements of the bombsight to be followed by the searchlight. The elevation master cylinder is secured to the yoke with its piston rod attached to the bombsight shaft. The azimuth master cylinder is mounted on the base with its piston rod attached to the yoke. To compensate for expansion and contraction of the hydraulic fluid due to temperature changes, an equalizer containing air under pressure is connected to the lines. Synchronizing screws are provided for synchronization of the searchlight with the bombsight. A hand pump, a reservoir, and a bleeder hose are furnished as maintenance equipment with which to fill and bleed the systems.

Since the "isodraulic" system furnishes sufficient dampening effect itself, no inertia tracking aid is installed. The elevation and azimuth scales provided in this modification indicate the position of the bombsight. The elevation scale is graduated from zero to 40 degrees in depression, and the azimuth scale is graduated 20 degrees to the right and left of the center zero index. The right handle grip has two switches; one for the searchlight and the other for arming. The microphone switch is located in the left handle.

The Mk 23 Mod 7 sight is designed for use in patrol type aircraft. It is mounted on an Aero 1A bombsight mount, and is located so as to permit direct view sighting through the bombardier's window in the nose of the aircraft.

The Mk 23 Mod 9 bombsight is an adaptation of the earlier Mod 4 sight, but has been given the handle grips of the Mod 7 sight. (See fig. 7–10.) This modification incorporates a synchro transmission system which controls the searchlight. A potentiometer pickoff circuit which is entirely independent of the synchro system is provided to actuate the PDI (pilot

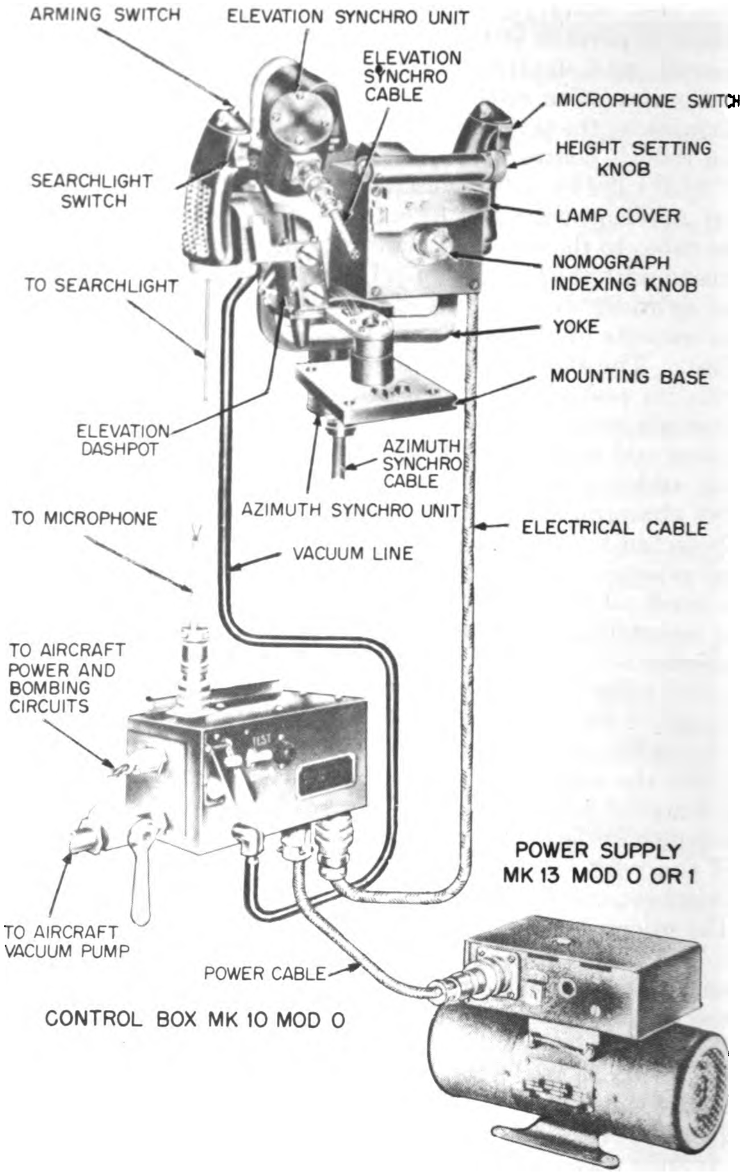


Figure 7–10.—Bombsight Mk 23 Mod 9.

director indicator) to indicate movements in azimuth. An additional switch has been provided in the right handle grip to operate the searchlight.

The sight mounting base has been modified to permit attachment of the azimuth synchro housing, and the sight mounting yoke modified to permit attachment of the elevation synchro mounting bracket. The azimuth and elevation synchro systems are two separately operated control units each having a "generator" and a "motor." These are not generators and motors in the ordinary sense of the word. Their shafts do not turn, or rotate, at any given number of revolutions per minute. The "generator," whose shaft is turned through a gear meshed to the movements of the tracking head, sends electrical impulses to the "motor" causing its shaft to turn exactly the same number of degrees. In this manner the searchlight, which is attached to the "motor," is made to move in direct synchronization with the bombsight which is geared to the "generator." Thus, the searchlight follows the movements of the bombsight to illuminate the target.

The Mk 23 Mod 10 bombsight contains primarily the same circuits as found in the earlier modifications. It is mounted on a modified yoke which permits the tracking unit to be rotated about its vertical axis for better viewing by the operator when adjusting the tracking head for the bombing run. It is mounted in a forward gun turret and tied directly to the movements of the turret. (See fig. 7–11.) A spring locking device locks the tracking head along the fore-and-aft axis when adjustments are completed.

The Mk 23 Mod 10 contains a Mk 81 Mod 0 computer, a Mk 33 Mod 0 control box, and a Mk 13 Mod 0, or 1, power supply. This is the first mention that has been made of the Mk 81 Mod 0 computer. **THIS COMPUTER IS ESSENTIALLY THE MK 23 MOD 6 TRACKING HEAD WITH THE MOUNTING YOKE AND CONNECTING LINKAGE REMOVED.** The linkage is no longer needed since the computer is designed to be mounted on the control box Mk 33 Mod 0. The arming switch and microphone wires have also been removed. The Mk 23 Mod 10 functions in the same manner as the earlier modifications, but differs in that it is installed in a turret.

The Mk 33 Mod 0 control box has been redesigned to pro-

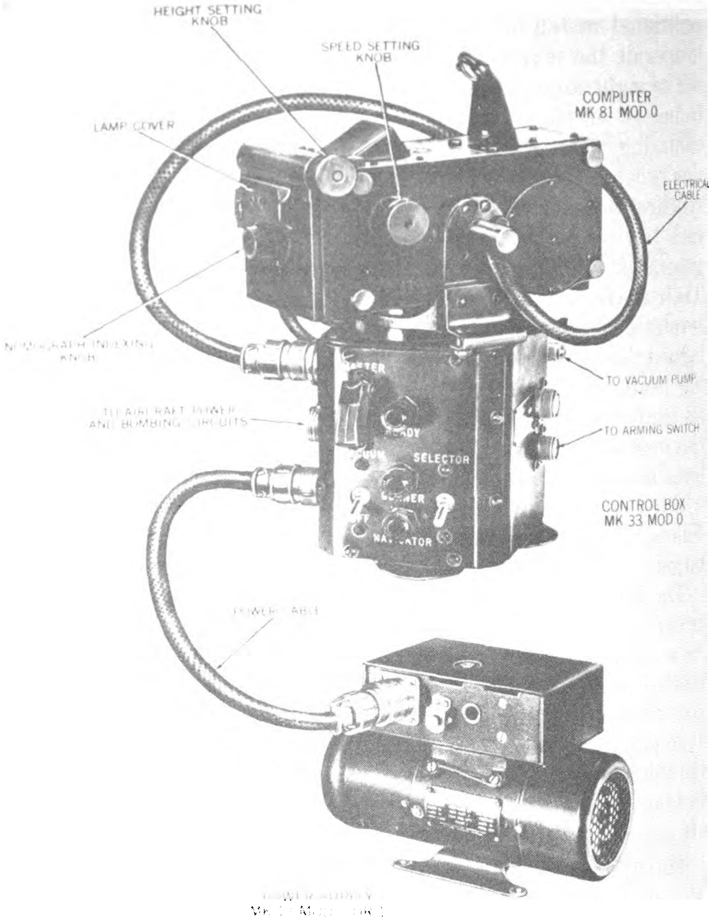


Figure 7–11.—Bombsight Mk 23 Mod 10.

vide a mounting for the Mk 81 Mod 0 computer, and to allow for a more convenient grouping of switches. The master switch energizes the Mk 13 Mod 0, or 1, power supply, the nomograph lamp in the computer, the ready lamp, and the relays in the control box. The vacuum switch controls the power to the vacuum pump. The selector switch is used to transfer control of the tracking during the bombing run from the operator in the turret to the navigator for radar tracking when weather conditions do not permit optical tracking. There are three indicator lamps: the RED ready lamp, the GREEN gunner's lamp, and the BLUE navigator's lamp. These lamps may be checked by pushing in one the lamp knobs. This action disconnects the lamp from the test circuit and connects it directly to the positive side of the main power supply circuit. If the lamps fail to light during the test, they are bad and must be replaced.

INSTALLATION.—Installation of the Mk 23 bombsight will necessarily vary in different types of aircraft. Descriptions in this chapter regarding installations will therefore cover only general installation requirements. The stand for the Mk 23 bombsight must be mounted in a forward position within the aircraft which will permit the line of sight to be rotated from zero degrees to 30 degrees depression. It should be located so as to give the operator maximum freedom of movement while using the sight. Arm rests should be provided if possible. The Mk 23 Mod 4 has to be mounted in a special antivibration unit which is supplied by the Bureau of Aeronautics.

The control box should be mounted on the left side of the sight, preferably on a bulkhead. Mounting on the left side permits shorter electrical and vacuum lines to the sight. The motor alternator (inverter) may be located at any convenient location not over five feet from the control box, as this is the overall length of the connecting cable.

After the components of the Mk 23 sight are installed, they are interconnected and then connected to the aircraft's electrical supply and to the vacuum source. Final connections are made to the bomb release circuit of the aircraft.

The Mk 23 Mods 5 and 10 require different installation procedures. The Mk 23 Mods 5 and 6 make use of a periscope for tracking and may be installed in any convenient location within the aircraft, regardless of the lack of forward vision, as long as the periscope refractor assembly has an unobstructed forward view of 30 degress in depression. The Mk 23 Mod 10 is installed in the forward gun turret of the aircraft. It is mounted on top of the control box (Mk 33). The tracking head and control box combination is then mounted directly to the movable structure of the turret, to the right and above the operator. The illuminated gunsight of the turret is used to track the target through the normal movement of the turret in depression. The angular tracking rate is introduced into the bombsight by the downward rotation of the turret relative to the aircraft as the target approaches.

MAINTENANCE.—Line maintenance of the Mk 23 bombsight and its different modifications should be limited to routine operational checks and adjustments, and to the replacement of parts furnished either as operating spares or those to be found in the line maintenance spare parts set. These spare parts are listed in NAVORD List No. 22836, Revision "A," of NAVORD List 21416, Revision "C" of April 1953. Certain portions of the bombsight are ACCESSIBLE ONLY THROUGH HERMETICALLY SEALED ACCESS DOORS. For purposes of line maintenance these access doors (covers) should be considered permanently sealed. Any maintenance work involving the gyroscope compartment, pneumatic block compartment, or the diaphragm switch (pneumatic switch) compartment should not be attempted.

The gyroscope compartment access cover plate forms a closely fitting part of the outer body of the sight on the right side under the handle grip, the pneumatic block compartment access cover plate fits in the same manner on top of the sight, and the diaphragm switch (pneumatic switch) compartment access cover plate is secured to the left aft side of the sight. These compartments should be opened only by qualified personnel at overhaul activities. The following are items of routine maintenance to be performed by maintenance personnel on the Mk 23 bombsight.

After 25 hours of sight operation, the following check should be performed. Any erratic operation of the sight prior to this time limit is sufficient cause to perform this check immediately:

1. Check the electrical connections to the junction box, sight unit, and the power supply to insure that they are all tight and that there are no frayed cables.

2. Check the vacuum connections from the junction box to the sight unit and to the aircraft vacuum system. With a vacuum gage, check the adjustment of the pressure regulating valve. Set the valve so that a vacuum of 4 inches of mercury is available at the sight unit. Accurate adjustment of this valve is imperative for satisfactory operation of the sight.

3. Insure that the correct nomograph is installed for the type of aircraft being used, and that there are no tears and bends in the film. Also check the height scale for tears and dust accumulation thereon. If the nomograph is damaged or of the wrong type, replace it. To do this remove the front cover and the lamp contact block. Take out the large screw in the center of the nomograph indexing knob. With a smooth piece of cardboard or metal, carefully bend down the nomograph film cone so that it will clear the top of the sight housing while sliding the nomograph assembly off along its shaft. To replace the nomograph, reverse the above procedure. However, do not overtighten the screw in the nomograph indexing knob as it is possible to slip the shaft in the sight and destroy the calibration.

4. Turn on the sight and let it warm up for 15 minutes.

5. Perform the routine operational check to insure that the test circuit is operating correctly. If the test lamp is burned out, replace it from the line maintenance spare parts set.

6. Check the nomograph lamp and the sight lamp. You will find replacements for the nomograph lamp in the line maintenance set. The sight lamp is the same one used in the Mk 9 illuminated sight.

7. Check the dimmer switch assembly by looking through the sight while turning the rheostat through its full range. Should the dimmer switch be defective, replace it from the line maintenance spare parts set.

8. Replace the air filter located on the right-hand side of the sight body. The filtering element will be either glass wool or layers of wire mesh, depending on the particular modification of the bombsight being used. Remove the old glass wool filter in its cylinder assembly and replace it with a new one from the line maintenance set. Remove the wire screen mesh filter from the bombsight, disassemble by removing the retainer ring, and clean and replace the separate wire mesh layers.

9. Check the cyclic rate of the power supply from the motor alternator. The regulation of the output of this unit to 400 cycles per second, plus or minus ½ of 1 percent, is EXTREMELY CRITICAL AND GREATLY AFFECTS THE ACCURACY OF THE EQUIPMENT. This check is made by connecting a frequency meter (Model 33F) in parallel with one phase (110 volts) of the

three-phase power supply. To accomplish this, remove the cover of the junction and regulator box on the power supply, connect one terminal of the meter to one of the 110-volt terminals and the other to the framework of the power supply for the ground. Adjust the cyclic rate by means of the adjusting screw and locknut on the end of the spring supporting the contact point nearest the center. The cyclic rate governor is located on the motor alternator fan.

10. While making the above check it is a good idea to clean and check the governor contact points with a cloth moistened with cleaning solvent. DO NOT USE CARBON TETRACHLORIDE FOR THIS. File off any projections that may have built up from arcing of the points before attempting to adjust the points.

11. Tighten the setscrews on the sighting head (tracking head) handles and the height scale.

12. Replace all covers, recheck the sight by means of the test circuit, and turn off the switch.

At the end of 50 hours of sight operation, a more detailed check is made on the sight. This check includes all the items of the 25-hour check outlined above in addition to the items listed on the 50-hour check below:

1. If the governor assembly shows excessive wear, replace the governor and slipring assembly from the line maintenance spare parts set.

2. Inspect the motor alternator brushes. Clean them and see that they are no shorter than $\frac{9}{32}$ inch. While removing these brushes, make certain to note the terminal and position in which each brush is installed. Mark the top of each brush with a plus or minus sign (whichever is correct for the terminal concerned) so that they may be replaced correctly. Clean the brushes with a cloth moistened with carbon tetrachloride. If the brushes are determined to be worn beyond service, replace them (the d-c, a-c, and motor alternator section brushes) with the spares in the line maintenance set. Install the new brushes with their polarity signs facing up. Fit the brushes to the commutator by inserting a strip of No. 000 sandpaper between the brushes and the commutator and pulling the sandpaper in the direction of commutator rotation. Repeat until the brushes are fully seated. Be sure to remove all sand and brush particles completely.

3. If the commutator is dirty, clean with cleaning sol-

vent—NOT CARBON TETRACHLORIDE. If the surface feels rough, turn on the power and hold a strip of No. 000 sandpaper against the commutator until the surface is clean and smooth. Again remove all traces of sand and brush particles. After replacing brushes and cleaning commutator, run the motor alternator until a brownish commutator film is formed. Check and adjust the cyclic rate if necessary and replace the cover.

Caution: Since this alternator normally runs at 12,000 r. p. m., take precautions for the safety of those concerned while running this alternator with the covers removed.

4. Clean the regulator valve located in the junction box. Remove the four screws which fasten the valve cover to the valve body thereby exposing the disk and spring. Remove the disk and spring and clean with a soft cloth. Do not use abrasives. Reassemble and replace these parts in the junction box, but do not apply oil or grease to the valve bearing—it should operate freely without lubrication. If the valve shows excessive wear, it should be replaced with a new valve unit from aviation stock.

5. Clean the relay contacts in the junction box with a clean dry cloth.

6. If, after cleaning and oiling, the inertia tracking assembly does not provide smooth performance, it may be removed from the sight as its removal does not greatly affect the accuracy of the sight. However, if the tracking aid is removed, a means of securing the sight while not in operation should be provided.

7. If repairs in excess of those outlined in the two above checks are found to be necessary, the sight should be returned for overhaul.

Most of the modifications of the Mk 23 bombsight are repaired and maintained in the same basic manner. However, there are certain modifications which require slightly different maintenance and repair due to differences in mounting, connecting linkages, accessory drives (electrical and hydraulic), and types of sighting employed.

In the Mk 23 Mod 6 bombsight, for instance, the pair of levers and the adjustable link which connects the bombsight shaft to the periscope will need added attention to assure smooth operation.

The Mk 23 Mod 7 bombsight installation makes use of an "isodraulic" system for the operation of a searchlight in conjunction with the normal functions of the bombsight as has been shown above. The maintenance of this system is as follows:

1. To get the maximum efficiency of operation through wide temperature ranges to be anticipated in aircraft equipment, it is necessary to employ a special "isodraulic" fluid for the searchlight operating gear. This fluid may be made by mixing together hydraulic fluid and compass liquid in the proportions of 20 and 80 percent by volume respectively, or by using one of several commercially prepared fluids.

2. The initial air pressure in the equalizer determines the torque that can be transmitted by the system without loss of synchronism. The number of pounds per square inch of air pressure should be numerically 100 more than the maximum torque to be transmitted (measured in inch-pounds), i. e., for a torque of 0 inch-pounds, the initial pressure should be 100 pounds per square inch; and for a torque of 200 inch-pounds the initial pressure should be 300 pounds per square inch, etc. The initial pressure should never be greater than 500 pounds per square inch. The air chamber of the equalizer may be charged from an air flask or by means of a booster pump.

3. The magnetic needle on the side of the "isodraulic" equalizer follows the piston, which determines the amount of fluid stored in the equalizer and the reserve expansion volume. The total volume of the equalizer is sufficient to handle the volume change of the fluid in a 50-foot system using 1/4 × 0.035-inch tubing, and in a 100-foot system using 3/16 × 0.035-inch tubing through a temperature range of 225 degrees Fahrenheit. When this temperature range extends from −65 degrees to +160 degrees Fahrenheit, the system should be filled to a level corresponding to the prevalent temperature.

4. In servicing this system, and before bleeding and filling, charge the equalizer with air as noted above. To bleed and fill the "isodraulic" system, remove the inlet check valve cap and connect the hand pump or fluid pressure source. Attach a standard bleeder hose and loosen the bleeder screw. Pump fluid through the line and cylinder and out at the bleeder screw, reversing the master or slave lever until there

is no evidence of air coming from the bleeder hose. Tighten the synchronizing screw and repeat on the other cylinder. Close bleeder screw, and with one synchronizing screw open, pump in fluid until the indicator needle reaches a point corresponding to the correct prevalent temperature. Disconnect the hand pump and replace the inlet check valve cap. Finally, synchronize the master and slave cylinders and tightly close the synchronizing screws.

5. Lubrication of the "isodraulic" units' levers and links should be performed frequently with a light oil.

Maintenance of the Mk 23 Mod 9 bombsight is the same as that for the other modifications except for the elevation and azimuth synchros that have been added to the basic unit to control the movements of the searchlight. Maintenance of these synchros involves more precise procedure, tools, and technical know-how than normally found in operating activities. Instructions on maintenance of synchros are therefore definite and explicit. Never attempt to lubricate a synchro. Never take a synchro apart because they are sealed, and these seals should be broken only by technicians in authorized repair shops. If the synchro is working without trouble, it should be left alone. If it becomes faulty, it should be replaced. If faulty wiring is suspected, check out all the leads with an ohmmeter or test lights for incorrect wiring, shorts, open circuits, and faulty rheostats. The gears meshing the azimuth and elevation synchros to the sight should be cleaned and oiled regularly. These gears will have to be remeshed exactly or the system will not operate properly. The procedure for zeroing the components will not be given here as it is too involved, and may be found in detail in OP 1303.

The Mk 23 Mod 10 bombsight is basically maintained as outlined in the 25- and 50-hour checks previously detailed. However, since the Mod 10 has a completely changed control box and certain alterations have been made to the mounting yoke and sighting head (redesignated Mk 81 Mod 0) some of the maintenance procedures will be different.

The maintenance on the Mk 81 Mod 0 computer (of the Mk 23 Mod 10 bombsight) is the same as for the other modifications except that the previous type of mounting yoke and the linkage have been eliminated in the Mod 10.

Prior to any disassembly of the Control Box Mk 33 Mod 0 for maintenance and repair, the complete test for malfunctioning specified in NAVORD OD 7805 should be completed. After completion of this test the control box should be disassembled only to the extent indicated by the test when replacing or repairing defective parts and assemblies. For full details of the overhaul and repair of the Mk 23 Mod 10 bombsight, refer to OP 1316B, Change 3.

QUIZ

1. There are two relays in the Mk 23 control box, a single and a double. The single relay acts as a
   a. safety for the double relay
   b. switch to close the bomb circuit to the bomb store
   c. means of applying input power
   d. TEST or BOMB switch
2. If the output of the inverter fluctuates, the
   a. gyroscope will tumble
   b. gyroscope precessional force is effected
   c. bombs will release early
   d. bombs will release late
3. Turning the groundspeed knob causes
   a. the nomograph disk to move
   b. the gyroscope speed to change
   c. spring tension to change
   d. vacuum pressure to change
4. The Mk 23 Mod 5 sight is used in
   a. a periscope installation
   b. a bow turret installation
   c. conjunction with radar, with radar controlling the sight
   d. any installation forward of the pilot
5. There is no sight attached to the tracking unit in the Bombsight Mk 23
   a. Mod 0
   b. Mod 4
   c. Mod 9
   d. Mod 10
6. The line of sight in figure 7-1 is the line from
   a. *A* to *B*
   b. *B* to the water
   c. *P* to *B*
   d. *P* to *T*

7. Information obtainable from the nomograph disk includes
   a. stick length, altitude, and bomb type
   b. stick length, bomb type, and drift
   c. estimated groundspeed and intervalometer setting
   d. time constant, parallax, and rack delay

8. Some advantages of low level bombing over high level bombing are
   a. no computations of trail or cross trail necessary
   b. less danger from antiaircraft fire and fighter aircraft attack
   c. no computations of bomb type necessary with airspeed constant
   d. an automatic solution without human error introduced

9. The Mk 23 sight requires a maximum downward depression when installed of
   a. 40 degrees
   b. 30 degrees
   c. 20 degrees
   d. 50 degrees

10. One of the factors to be considered when installing the Mk 23 is
   a. pilot error in airspeed
   b. a means of computing drift or target motion
   c. freedom of movement for the operator
   d. loss of airspeed caused by the installation

11. The delay caused by the dampening of pneumatic cup signals is corrected by
   a. seaman's eye
   b. an increased vacuum
   c. nomograph construction
   d. restrictions in the vacuum line

12. Movement of the arm that is connected to the pneumatic cups is caused by
   a. vacuum pressure
   b. spring tension
   c. gyroscopic precession
   d. a combination of gyroscopic precession and spring tension

13. What directly controls the speed of the gyroscope?
   a. Centrifugal force
   b. Output voltage
   c. Induced voltage
   d. Cyclic rate (400-cycle current)

14. What actuates the release circuits?
   a. Gyroscope
   b. Pneumatic cup
   c. Pneumatic block
   d. Pneumatic switch

15. The 0.80 second delay in the Mk 23 sight is called
   a. time delay
   b. time constant
   c. relay delay
   d. switch delay

16. Unless making a live run the TEST-BOMB switch should always be on the
   a. ON position
   b. OFF position
   c. BOMB position
   d. TEST position

17. When the gyroscope precesses, it overcomes
   a. the calibrated spring
   b. the vacuum pressure
   c. the precessional torque
   d. atmospheric pressure

18. The gyroscope is a synchronous induction type motor which operates on
   a. 115-volt, 3-phase, 300-cycle a.c.
   b. 115-volt, 3-phase, 400-cycle a.c.
   c. 115-volt, 3-phase, 300-cycle d.c.
   d. 115-volt, 3-phase, 400-cycle d.c.

19. The gyroscopic spin rate is
   a. 10,000 r.p.m.
   b. 12,000 r.p.m.
   c. 14,000 r.p.m.
   d. 15,000 r.p.m.

20. The cyclic rate must be maintained at what percent of its rated figure?
   a. 0.3
   b. 0.4
   c. 0.5
   d. 0.10

21. The correct order in setting in of a bombing problem is
   a. stick length, groundspeed, altitude
   b. groundspeed, altitude, stick length
   c. altitude, groundspeed, stick length
   d. stick length, altitude, groundspeed

22. The squadron ordnanceman should not perform any work on the
   a. control box
   b. inverter
   c. gyroscope
   d. Mk 9 sight

23. The airspeed limits for use of the Mk 23 sight are
   a. 120 to 300 m.p.h.
   b. 200 to 300 m.p.h.
   c. 120 to 300 knots
   d. 200 to 300 knots

24. In order to drop a store you must
    a. depress the arming switch
    b. open the vacuum source valve
    c. put TEST-BOMB switch to BOMB
    d. all of the above

25. Before making a bombing run the Mk 23 sight should be warmed up at least
    a. 5 minutes
    b. 15 minutes
    c. 25 minutes
    d. 30 minutes

26. You should make how many test (dummy) runs before making a live run?
    a. none
    b. 1 to 2
    c. 2 to 3
    d. 3 to 5

27. The Mk 23 Mod 10 sight is
    a. used in patrol aircraft
    b. mounted in the forward gun turret
    c. mounted in any gun turret
    d. used in fighter aircraft

28. Vacuum pressure is supplied to the tracking head through the
    a. right trunnion
    b. left trunnion
    c. sight unit
    d. inverter

29. All nomographs are designed for the first bomb to fall
    a. 25 feet short of target
    b. 35 feet over the target
    c. 35 feet short plus one-half the stick length
    d. 55 feet short plus one-half the stick length

30. How many nomographs are on a disk assembly?
    a. 4
    b. 6
    c. 8
    d. 10

31. There are how many groundspeed lines on a nomograph?
    a. 4
    b. 6
    c. 8
    d. 10

32. The Mk 23 sight is a
    a. medium level bombsight
    b. high level bombsight
    c. angle of depression type
    d. angular rate of depression sight

33. The altitude limits above target for use of the Mk 23 sight are
- a. 50 feet to 100 feet
- b. 50 feet to 300 feet
- c. 50 feet to 500 feet
- d. 50 feet to 1,000 fet

34. The Mk 23 sight solves what part of the bombing problem?
- a. Gravity
- b. Range
- c. Cross trail
- d. Ballistic

35. The Mk 23 sight does not compute for
- a. gravity
- b. elevation
- c. azimuth
- d. range

CHAPTER 8

TOW TARGETS

Aerial tow targets and related equipment are used for both air-to-air and antiaircraft gunnery exercises, thus providing training for the fleet against enemy airborne targets. Towing for antiaircraft firing is usually done by the Navy's utility squadrons, while towing for air-to-air gunnery is usually done by combat aircraft from the squadrons involved.

One section of this chapter describes the various items of equipment, such as targets, reels, cables, and other items; while the other section discusses towing techniques.

TOWING EQUIPMENT

Targets

There are three basic types of targets: banner, sleeve, and winged. Table 8–1 gives the general specifications of several current types of targets.

Banner targets are panels or "flags" of polyethylene or polyethylene and aluminum foil material. The banner may be towed in either a vertical or horizontal position by shifting a counterweight. (See fig. 8–1.) The banner target presents a greater area than a sleeve target for recording hits. The banner has poor aerodynamic properties which make it unsuitable for high-speed towing. It is bulky to handle, and when streamed presents a target in only one plane—vertical or horizontal, depending upon the position of the counterweight.

Sleeve targets are in the shape of a truncated cone, open at the throat, and with a closed hemispherical breech. They have wire-bearing fabric panels for radar reflection, thus allowing them to be used as targets for radar-aimed antiair-

Table 8–1.—General characteristics of tow targets.

TARGET	Aero 27A	Mk 23	Type A–25B	Type A–10.
USE	Air-to-air antiaircraft.	Air-to-air antiaircraft.	Air-to-air	Air-to-air.
SHAPE	Swept-wing	Truncated cone	Banner	Banner.
SIZE	Span, 18 feet 2 inches; length, 19 feet 2 inches.	20 feet long, 31-inch diameter.	30 feet long, 6 feet wide.	20 feet long, 4 feet wide.
TYPE OF NOSE RING		Solid		
WEIGHT	350 pounds	12.5 pounds	40 pounds	25 pounds.
LAUNCHING METHOD.	Drag	Manual, container	Drag or carrier	Drag or carrier.
LAUNCHING SPEED, KNOTS IAS* (MAX.).		120		
TOWING SPEED, KNOTS IAS* (MAX.).	Mach 0.82 (Max.)	260	220	200.
COLORS	Red	Mod 0, Red; Mod 1, Black; Mod 2, White.	Gray	Gray.
RADAR REFLECTING	Yes	Yes	Yes	Yes.

*Indicated airspeed

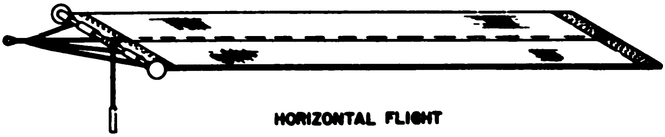


Figure 8-1.—Banner Target Type Aero 25B rigged for horizontal flight.

craft guns. Battery-operated lights may be installed in antiaircraft targets to permit night use.

While the sleeve target presents a smaller target than does a banner, the sleeve may be towed 30 to 50 knots faster. The current sleeve targets are made of rayon, but orlon targets able to stand more hits without ripping are under development. The truncated-cone, closed-breech target is illustrated in figure 8–2.

Winged targets, as the name implies, resemble airplanes in appearance. Because of the high cost of each target (from about $1,500 to more than $2,500 each, depending on the type), the winged target is not extensively used. However, it is by far the most realistic of the towed targets, since it not only resembles a plane but flies as it is being towed through the air. It simulates the maneuvers of the towing aircraft, including banking turns.

The latest type of winged target is the Aero 27A, modified swept-wing version, shown in figure 8–3. This is an all-metal target of high-speed, low-drag design, and suitable for both air-to-air and antiaircraft gunnery exercises. It is towed from the runway by the towing aircraft and upon completion of firing is landed behind the towing aircraft. The target has an automatic release mechanism which releases it from the plane as soon as the target contacts the ground. At the same time an 8-foot parachute is released from the upper aft fuselage to shorten the landing run and to prevent target damage.

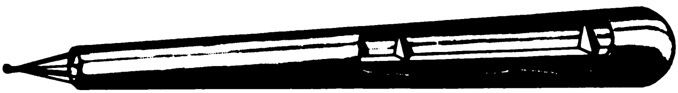


Figure 8–2.—Antiaircraft Target Mk 23 and Mods.

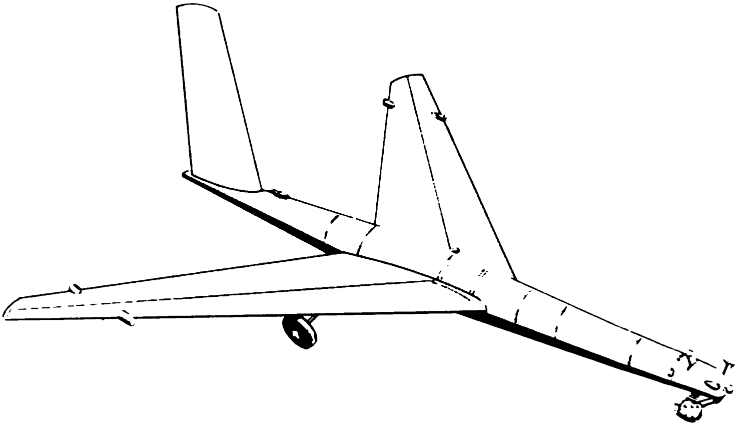


Figure 8–3.—Swept-Wing Target Aero 27A. (Red Bird.)

Reels

A reel-equipped towplane provides the most flexible method of launching and towing aerial targets. Any sleeve target may be launched manually in flight from the towplane, and targets may be exchanged at will. Each used target may be jettisoned in flight by streaming a new one down the cable. Thus during one flight, a single plane may tow for both air-to-air and antiaircraft gunnery exercises and may stream a succession of targets to permit prolonged firing.

This chapter discusses only the Mk 8 reel. An earlier reel, the Mk 5, is now infrequently used and has been superseded by the Mk 8. Due to space limitations, a detailed description of the operation of these reels is impossible in this text. The Aviation Ordnanceman in a utility squadron, who may need to know tow target equipment more thoroughly than is presented here, is referred to the NAVAER and AN publications on the subject.

Antiaircraft Target Reel Mk 8 Mod 0

The Mk 8 reel is a hydraulically driven unit designed to hold, reel in, store, and reel out a maximum of 12,000 feet of ⅛-inch diameter, 7 x 19 or 1 x 19, steel tow cable.

The major parts of the Mk 8 reel (fig. 8–4) are the left- and right-hand frames held together by tie rods and spacer tubes;

the screens which enclose the front, top, and ends of the reel; the clutch drum; brake; and the freewheeling, drive, and level-wind assemblies. With the clutch DISENGAGED, the drum is free to rotate in either direction. If the tow cable is reeling out, the speed of the drum is controlled by the brake. With the clutch ENGAGED, the drum is connected to the main shaft and is prevented from turning in the reeling-out direction by the freewheeling assembly. At that time, however, it can turn in the reeling-in direction, and the fluid motor drive assembly supplies the necessary power to reel in the cable. The level-wind assembly guides the cable so that it winds upon the drum in level layers and reels in or out smoothly and evenly without backlash.

Some of the specifications of the Mk 8 reel follow:

Overall length	30.75 inches
Overall width	26.25 inches
Overall height	23.00 inches
Weight, empty	280 pounds
Weight with 12,000 ft. of ⅛-inch steel cable	650 pounds
Reeling-out speed (max.)	4,000 f. p. m.
Reeling-in speed (avg.)	1,200 f. p. m.
Allowed cable tension	2,000 pounds
Speed of hydraulic motor (max.)	3,600 r. p. m.
Hydraulic pressure (max.)	3,000 p. s. i.

The DRIVE ASSEMBLY (fig. 8–4), which includes the hydraulic motor, two sprockets, a roller drive chain, drive pinion, and a drive gear, transmits power from the motor to the main shaft of the drum assembly. There is an overall reduction of 9:1 between the motor and the main shaft of the drum assembly.

The FREEWHEELING ASSEMBLY allows the main shaft of the drum to turn in one direction to reel in cable, but it prevents rotation in the opposite direction when the clutch is engaged.

The DRUM ASSEMBLY consists of the main shaft, the drum core, and left- and right-hand flanges. The drum (on which the cable is wound) rotates in EITHER direction when the clutch is DISENGAGED; but when the clutch is ENGAGED, the DRUM and SHAFT remain STATIONARY, or they TURN TOGETHER as a UNIT to reel in cable.

The CLUTCH ASSEMBLY is located on the main shaft inside the drum next to the left-hand flange, as shown in figure 8–4. When engaged by movement of the clutch handle, the clutch locks the drum on the main shaft so that when the hydraulic

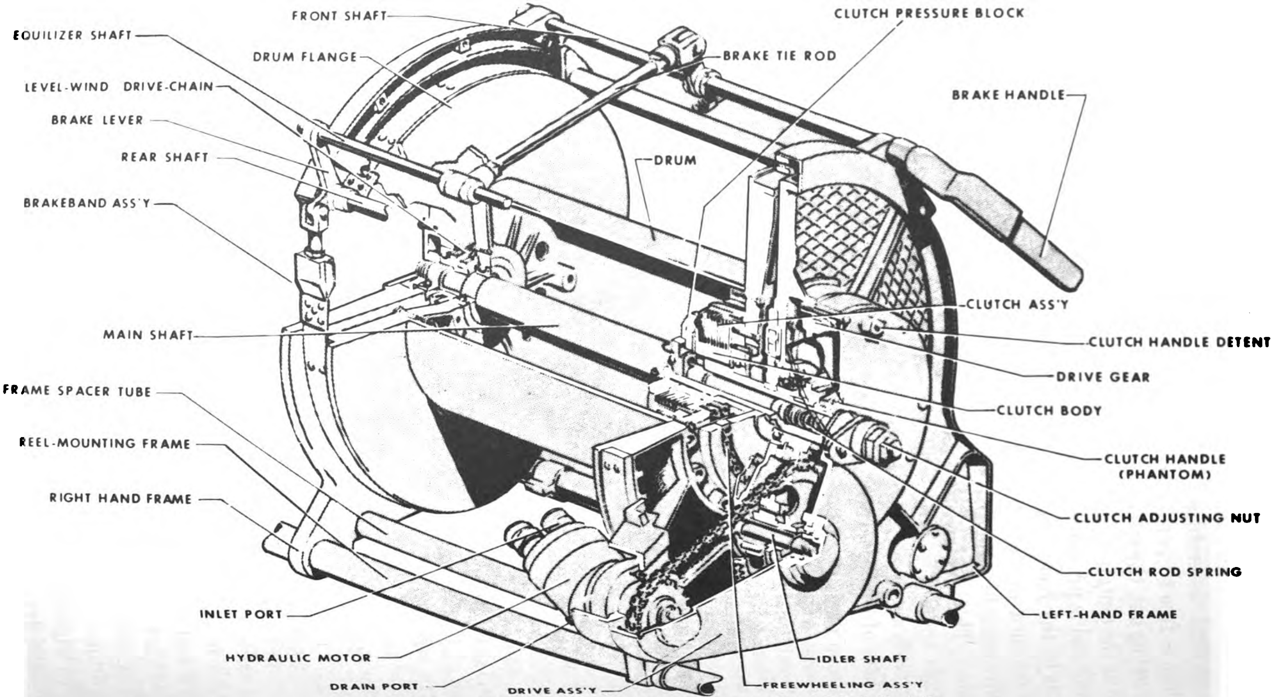


Figure 8—4.—Cutaway view Antiaircraft Target Reel Mk 8 Mod 0.

motor operates, the drum will turn and reel in the cable. When the clutch is disengaged, the drum is free to turn in the opposite direction to unwind the cable, although the main shaft will not turn with it due to the action of the freewheeling assembly. ENGAGE TOW REEL CLUTCH BEFORE TAKEOFF.

The BRAKE ASSEMBLY is used to control the speed of the drum when the cable is unreeling. Also, it is used to stop rotation completely before the clutch is engaged when the proper length of cable has unreeled. By pushing down on the brake handle, friction is applied by the brake bands on each drum flange. CHECK REEL BRAKE FOR PROPER OPERATION BEFORE TAKEOFF.

The LEVEL-WIND ASSEMBLY guides the cable so that it winds upon the drum in level layers, and reels in or out smoothly and evenly, without backlash.

Caution: Keep fingers clear of the level-winding mechanism when the reel is in operation.

OPERATION.—The only controls to operate on the reel are the clutch and the brake (fig. 8–4). A third control, the speed control valve, is located near the towman's hatch on the independent hydraulic power unit which supplies power to drive the hydraulic motor during reeling-in operation. The speed control valve should be in the OFF position at all times except when reeling in.

To reel out cable, place the clutch handle in the OUT position. The drum will revolve freely on the main shaft under the drag of the cable and target. The rotation of the drum will drive the level-wind mechanism and guide the cable as it leaves the reel. Pressure on the brake handle, which is pushed down to apply the brake, will control the speed of the drum. ALWAYS KEEP THE UNREELING OPERATION UNDER CONTROL OF THE BRAKE. IF THE CABLE UNREELS TOO FAST, IT MAY BACKLASH WITH DANGER OF A BREAK IN THE CABLE AND POSSIBLE DAMAGE TO EQUIPMENT OR INJURY TO PERSONNEL.

NEVER control the unreeling operation by slipping the clutch—applying the clutch while unreeling will cause immediate clutch failure. The drum must be brought to a stop by means of the brake before moving the clutch lever to the IN position. Only in case of an emergency caused by brake failure should the clutch be used to stop the drum. This action will ruin the clutch, but may avoid more serious results.

Stopping the drum is done by additional pressure on the brake handle. When the drum has been stopped, place the clutch lever in the IN position to engage the drum with the main shaft. The freewheeling mechanism will keep the drum from turning and unreeling more cable. At this point the brake is no longer needed and may be released.

The target must be released before reeling in is started. The clutch should be left in the IN position, and the brake OFF, as when towing. The speed control valve on the hydraulic power unit is then moved toward its ON position. This valve controls the amount of fluid passing through the hydraulic motor on the reel, hence it controls the speed of drum rotation. Reeling-in speed varies from 700 to 1,200 feet per minute. To stop reeling in, move the speed control valve to OFF, leaving the clutch engaged.

Caution: If the cable is reeled in too fast as the end approaches the outrigger, it may be impossible to stop the reel before the target release on the end of the cable reaches the outrigger tube projecting from the airplane. The outrigger leads the cable out from the reel and clear of the aircraft structure. Therefore, reel speed should be decreased as the end of the cable approaches. If the target release has been lost, the snarled end of the cable may be pulled through the outrigger, sheave, and level-wind follower, requiring realignment of the follower before the reel can be used again.

ADJUSTMENTS.—The reel should withstand 100 hours of operation without requiring replacement of any parts, or adjustment other than the clutch and brake bands. However, the reel should be thoroughly checked and lubricated every 25 hours of operation, up to the 100-hour point, when it must be completely disassembled and worn parts replaced. Detailed instructions for these maintenance procedures may be found in the NAVAER 28–10A–19 instructions dealing with the subject.

The CLUTCH ADJUSTMENT is extremely important. If necessary, the clutch is adjusted by first loosening the locknut just outboard of the clutch adjusting nut (fig. 8–4). Then with the clutch handle in the IN position, gradually tighten the clutch adjusting nut. Tighten until a dead load of 2,000 pounds can be applied tangentially to a full drum of cable without slipping when the load is suspended from the drum. (The manner in which the load is suspended from the drum depends upon individual squadron procedure.) When the clutch is properly adjusted, hold in the adjusting nut with one wrench while tightening the locknut against the adjusting nut with another wrench. Then with the clutch handle in the OUT position, check the drum for free rotation in both directions. With the clutch handle in the IN position, check for free drum rotation in the reeling-in position. The reel should now withstand all loads imposed during towing operations.

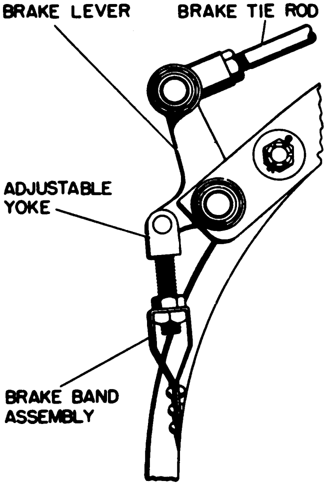


Figure 8–5.—Brake adjustment.

The BRAKE ADJUSTMENT is made by tightening or loosening the two brake bands. One end of each band is connected to an adjustable yoke, which is attached to a brake lever. This lever should not be confused with the BRAKE HANDLE. The brake band is tightened by disconnecting the adjustable yoke from the brake lever (figs. 8–4 and 8–5), by loosening the upper nut on the brake band, and by turning the adjustable yoke clockwise to the desired position. The nut is then tightened and the yoke and brake lever reassembled. To loosen the brake band, the same procedure is followed except that the adjustable yoke is turned counterclockwise.

When the aircraft's hydraulic system cannot be used, the hydraulic power systems Aero 1A, 1B, 1C, and 1D transmit power from the aircraft engine to the reel. A reservoir supplies hydraulic fluid to a variable delivery pump driven by the engine. The pump creates the working pressure for the system and forces the fluid back to the other elements mounted on the reservoir. It passes through a check valve, a pressure relief valve, and then to the speed control valve mentioned earlier. This valve controls the speed of the reel's hydraulic motor (hence controls the speed of the drum when reeling in), and the fluid, after driving the motor, returns to the reservoir. There is no connection in any way with the plane's hydraulic system. The hydraulic power system weighs approximately 90 pounds when empty and 192 pounds when filled with the normal supply of 14 gallons of hydraulic fluid.

With the exception of the engine-driven pump, all basic elements are assembled on the reservoir, including an electrically-operated auxiliary constant delivery pump. The purpose of the auxiliary pump is to provide power for ground rewind. For proper operation, an air pressure of 12 pounds per square inch must be maintained on the fluid in the reservoir. The air valve shown in figure 8–6 is the means of admitting or bleeding air pressure. Dual-reel installations have a 4-way reel selector valve to select the reel hydraulic motor that is to be driven.

Towlines and Cables

STEEL CABLES used in target towing are manufactured specificaly for that purpose. They are of three types: the 3/32-inch, 7 x 7 cable; the 1/8-inch, 7 x 19 cable; and the 1/8-inch, 1 x 19 armored cable.

The 3/32-inch cable comes in 10,000-foot spools, has a minimum breaking strength when new of 920 pounds, and is 7 x 7 in construction—that is, it consists of 7 strands, each having 7 wires. It weighs 1.5 pounds per 100 feet.

The 1/8-inch cable is shipped in either 11,500- to 12,500-foot spools, or 7,000- to 7,500-foot spools, and has a minimum breaking strength when new of 2,000 pounds. It is 7 x 19 in

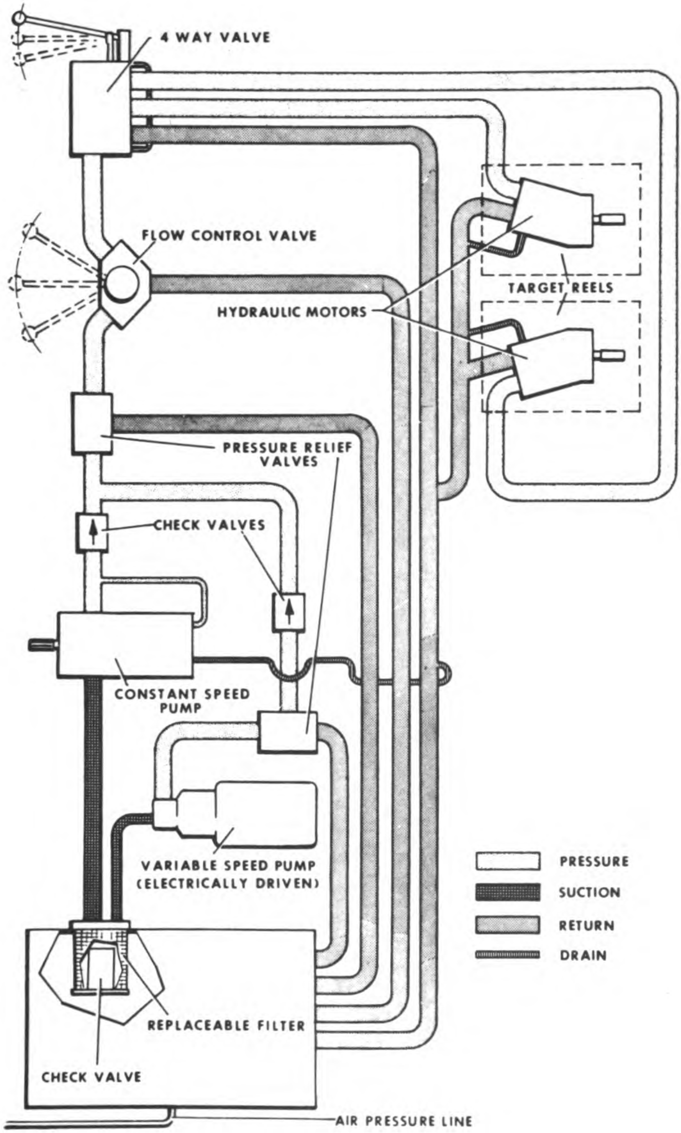


Figure 8–6.—Schematic diagram of Hydraulic Power System Aero 1C.

construction (7 strands, 19 wires to the strand) and weighs 2.9 pounds per 100 feet.

The ⅛-inch armored cable is shipped in spools. It has a minimum breaking strength of 2,160 pounds, and is constructed of one strand of 19 wires (Warrington design) with a flat armoring wire swaged spirally around the strand with a minimum of 6 turns per inch. The armored cable weighs 4.025 pounds per 100 feet. Cross sectional views of these three cables are shown in figure 8–7.

None of these cables are lubricated. Grease, oil, paraffin, or other lubricants on the cable create a fire hazard, since an explosive vapor in the towplane is created when the cable is reeled out at high speeds. However, since the cables are not lubricated, they must be kept in a dry place while in

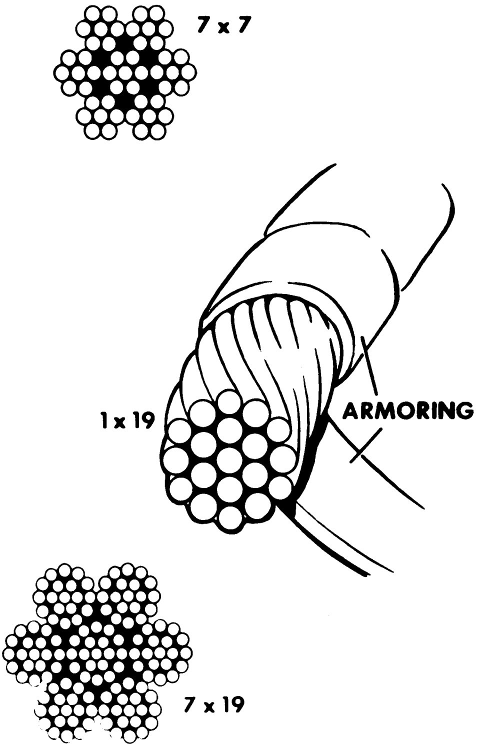


Figure 8–7.—Cross section of cables.

storage, or cleaned and coated with corrosion preservative compound in accordance with BUAER instructions.

Continued use of cable reduces its strength. Target towing subjects the cable to severe stresses in addition to damage by gunfire, and frequent inspections are advisable. The cable should be repaired or replaced as necessary if there are any indications of fraying (broken wires), birdcaging (partial unwinding of the strands along the cable), or snarling (unwinding of the strands and wires at the end of the cable). Running a cloth along the cable will help locate broken wires, as they will catch in the cloth. **NEVER RUN THE BARE HAND ALONG THE CABLE, SINCE THE BROKEN WIRES WILL CATCH IN THE FLESH.** Never use a knot in cable to bend on a target, since this will weaken the cable 50 percent or more. An eye splice is recommended for this purpose.

TOWLINES, used for most towing operations when target reels are NOT employed, are made of either manila or nylon. MANILA line is either 15-thread (3 strands, 5 threads per strand), or 21-thread (3 strands, 7 threads per strand). Manila may still be used, but has generally been replaced by nylon towlines. NYLON line is procured especially for towing. It is 1¼ inches in circumference, 24-thread (3 strands, 8 threads per strand), and when new has a breaking strength of 3,900 pounds. Nylon line is shipped in 900-foot rolls and weighs 5.1 pounds per 100 feet.

Drag takeoffs are particularly hard on towlines and they must be inspected frequently. Towline should be stowed in a clean, dry, well-ventilated place.

Target Release Mk 7 Mod 3

The Target Release Mk 7 Mod 3 is a 2.5-pound device used to hold a target at the end of a cable and permit the exchange of targets while in flight. It is used only when towing with reels. During an exchange of targets while in flight, the release ring of the new target travels over the vertebrae of the release and forces the release trigger aft (fig. 8–8). This action depresses the forward end of the latch, moving the latch hook up to allow the ring of the used target to drop free. As the ring of the new target continues aft, it forces the latch back to its original position so that it catches and holds the ring. At the same time the

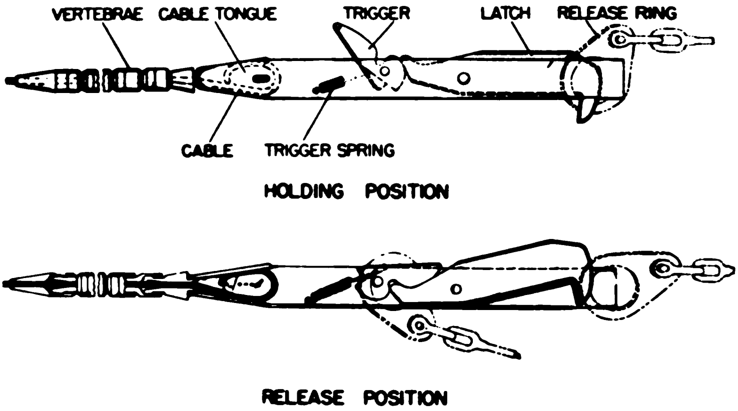


Figure 8–8.—Target Release Mk 7 Mod 3, holding and release positions.

trigger returns to its original position through the action of the latch and a spring.

The release is easily secured to the tow cable. Before using, make certain the entire unit is free from cracks and breaks, and that the trigger and latch pivots are lubricated. Then pass the cable through the vertebrae and around the grooved edge of the removable wedge-shaped cable tongue and clamp it with the retainer wire which will hold the cable. Not more than a quarter inch of cable should project through the retainer wire. Pull on the cable to jam the cable tongue in position. The greater the pull exerted in flight, the tighter the retainer wire and tongue will grasp the cable.

Target Leader Mk 1

The Mk 1 leader is used to attach targets and target release messengers to the release ring which is held, in turn,

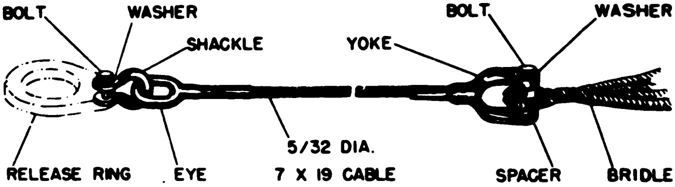


Figure 8–9.—Target Leader Mk 1.

by the Target Release Mk 7 Mod 3. When the target is dropped, the leader and ring drop with it. (See fig. 8–9.)

The leader is composed of a 34-inch length of $\frac{5}{32}$-inch, 7 x 19, steel cable, swaged into a yoke at one end and an eye at the other. To use the leader, secure the bridle eye of the target to the yoke of the leader. The eye end of the leader is secured with a shackle to the release ring or snarl catcher which slides along the tow cable.

Target Release Ring Mk 8

The Mk 8 ring is made of case-hardened alloy steel and is about 3 inches long. The smaller eye (fig. 8–10) is ½ inch in diameter, while the larger eye is 1½ inches in diameter.

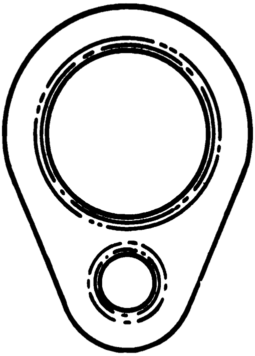


Figure 8–10.—Target Release Ring Mk 8.

The target leader is attached to the smaller eye (the securing eye). The larger loop (hole) slides along the cable and is held by the target release when towing with a reel.

Release rings are also used in drag takeoffs and container launchings. In the latter case, the ring is attached directly to the towline and then secured to the target release device of the airplane.

Klein "Chicago" Grip

This grip provides a means of transferring the target drag load from the reel to a structural member of the towplane and is used to take the strain off the reel while the target is streamed.

The grip is a standard commercial item, about 10 inches long, and composed of a series of spring-loaded linkages and a shackle. The jaws are opened by compressing the entire grip in line with the extended shackle. It will grip bare wires, solid or stranded, from 0.081 to 0.162 inch in diameter.

The grip is first secured by means of a cable to the plane's internal structure and is then attached to the tow cable near the outrigger sheave. Unwinding the reel slightly transfers the load from the reel to the grip. The greater the drag load, the tighter the jaws will grip the cable.

Caution: Do not apply loads greater than 1,500 pounds to the grip. It will accept cable with a much greater breaking strength than that of the grip itself. As a safety measure, set the reel brake while the grip is in use, keep the clutch in the IN position, and keep the slack in the tow cable between the grip and reel at a minimum.

Tow Webbing Assembly

The webbing assembly is a 100-foot length of cotton webbing with a parachute harness V-ring at each end. Also, there is a screw-pin shackle at one end for the attachment of the target bridle eye. The webbing is used between the target and the towline, and its use is mandatory in drag take-offs for air-to-air gunnery. Its purpose is to prevent the towline from being severed by gunfire, thus leaving the target in the path of the firing plane. Several fatal accidents have been caused by gunfire severing the tow cable. If the 100-foot webbing assembly had been used in these cases, the chances of such accidents occurring would have been remote.

Snarl Catcher Aero 1A

The snarl catcher is an all-steel device, used only when towing with a reel. It is used for attaching a leader and a target to the snarled end of a cable severed by gunfire or cut by a cable cutting messenger. It saves the time otherwise required to reel in the cable, attach a new target release, and launch a new target. The snarl catcher is illustrated in figure 8–11.

The snarl catcher, with leader and target attached, slides

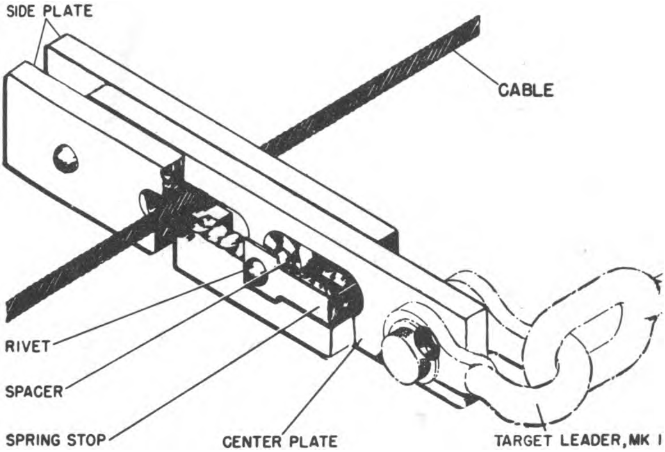


Figure 8–11.—Snarl Catcher Aero 1A.

freely down the cable until jammed by the snarled cable end. When the target is cut free, the snarl catcher drops free along with the leader and target.

Cable Cutting Messenger MK 7

This device has long been known as the IRON HORSE. It consists of a 6-inch octagonal windplate with a 6-inch body projecting from its center. The body contains a cable cutting edge and a spring latch for holding the messenger on the cable. The messenger is used only when towing with reels.

The iron horse is used in flight when it becomes necessary or advisable to cut a snarled or tangled tow cable at a distance from the towplane. If a target release becomes fouled or broken, or a snarl catcher is in use instead of a target release, it is necessary to cut the cable with the cable cutting messenger in order to drop the target. The messenger travels down the cable until it strikes an obstruction. The sudden stop causes its cutting edge to shear the cable. Of course, the messenger also drops free with the other equipment.

To use the iron horse, slip it on the cable through the transverse slot in the body (fig. 8–12). It is then turned so

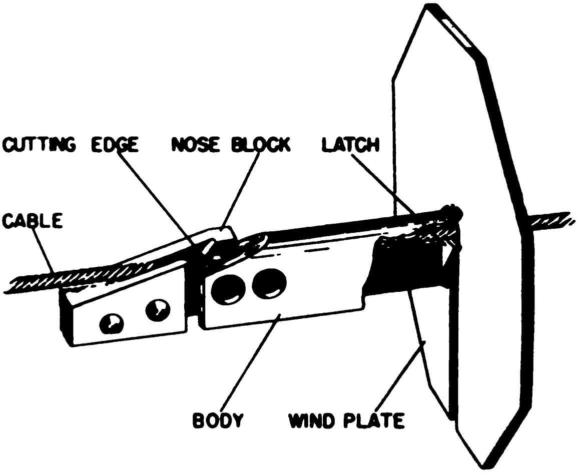


Figure 8–12.—Cable Cutting Messenger Mk 7.

as to pass the cable through the slot in the windplate, allowing the spring latch to hold the cable in place. The messenger should be launched body first (windplate aft), unless a previous messenger has been launched which failed to cut the cable. In this case, the second messenger should be launched windplate first, since the force of the second messenger hitting the first should be sufficient to cause the cutting edge of the first messenger to cut the cable.

Target Release Messenger Aero 10A–B

This messenger is used in flight to help prevent the tow cable from whipping while being reeled out or in, and to steady the cable while a new target is launched. It also serves as a point of aim during practice runs in aircraft gunnery. The Aero 10A messenger is a rayon cylindrical sleeve with a fully open throat and a partially open breech. It is 32 inches long, 12 inches in diameter, and the 18-inch bridle lines are secured to a solid steel nose ring. (See fig. 8–13.)

Aero 1A Banner Target Carrier

The Aero 1A target carrier is designed to enable carrier-type aircraft to air-launch banner targets after reaching the

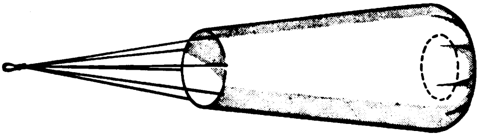


Figure 8–13.—Target Release Messenger Aero 10A.

firing area. It is the first such equipment to be produced for carrier-type towplanes. The construction of this carrier is such that it will withstand catapult launchings and arrested landings.

The Aero 1A is installed on the wing bomb rack of an aircraft. It is attached in the same manner as a bomb or other store. Figure 8–14 shows the banner target rolled up and fastened to the underside of the carrier. Two suspension cables fitted with swaged eye terminals through which latch pins are inserted are employed to secure the banner to the carrier.

Figure 8–15 shows the method of loading the Aero 1A carrier with the special jigs at each end. Four lengths of bungee cord with attached halyard snaps keep the towline in place. Each of the suspension cables passes through the thimble end of the bungee cord which retracts the cable on

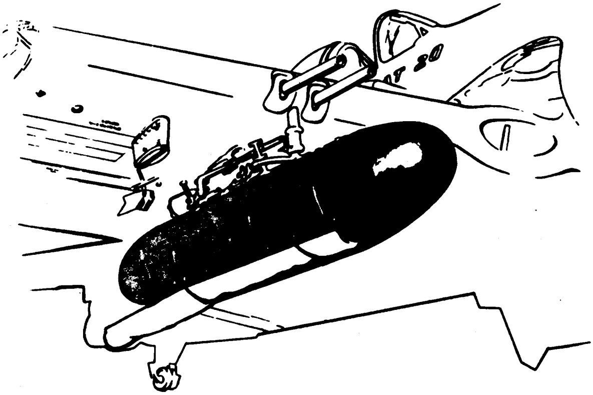


Figure 8–14.—Areo 1A target carrier installed on a wing bomb rack.

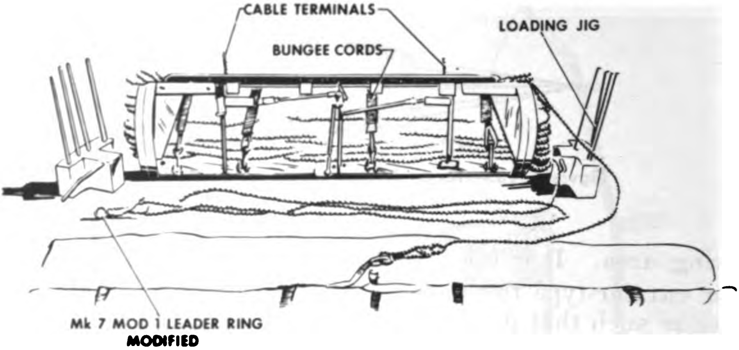


Figure 8–15.—Method of loading the Aero 1A target carrier.

release of the target. A leader ring is tied to the towing end of the towline and attached to the aircraft's tow release. The target release device consists of a solenoid and an enclosed coil spring. These retract the latch pins and launch the target when an electrical impulse actuates the bomb release.

Streaming the target from the towplane after reaching the firing area is a great improvement over other methods in which the target is dragged from the runway and towed to the firing area. Jet-type towplanes cause heavy damage to the target during drag takeoffs. This is mainly due to their relatively slow acceleration and long ground run before becoming airborne. The danger of stalling during the sharp pull-up necessary during a drag takeoff is eliminated by using the carrier launching method. Fuel is also saved, as well as time, getting to the firing area. Thus, more time is available to the towplane over the firing area.

Tow Target Container Mk 1 Mod 2

The Target Container Mk 1 Mod 2 is used to carry and release a target and towline in flight, if the aircraft is not equipped with a tow reel. (See fig. 8–16.) In order to mount this container, the aircraft must have a single or double hook bomb rack and a target release fixture. Up to 1,000 feet of towline may be carried in the container. The Mk 23 target may be used with this container. The target is launched by the pilot.

The Mk 1 container is constructed mainly of aluminum alloy sheet. The case is 48 inches long, elliptical in cross section, and closed at the forward end. A door at the aft end is held closed by a latch. This door is unlatched by a cable that runs to the bomb release solenoid (Aero 4B) mounted on the container. The Aero 4B solenoid release mechanism is being installed on all Mk 1 Mod 2 tow target containers to eliminate the manual release system previously employed. An elastic cord (bungee) is fastened to the container door and the suspension lug on top of the container. As soon as the door is unlatched, this elastic cord pulls the container door open and holds it in this position. Four brackets spaced around the open end of the container hold two bungee cords. When the door opens, these bungees pull out and forcibly launch the target.

To prepare the container for use, select 900 to 1,000 feet of towline and attach it to the bridle eye of the target. Level wind ten turns of this line around the folded target. Be careful not to damage the breaking cords which secure the target folds and the bridle lines. These ten turns are secured by taking a bight in the towline first under one side of the ten turns, then under the other.

From the other end of the towline, lay out a length suffi-

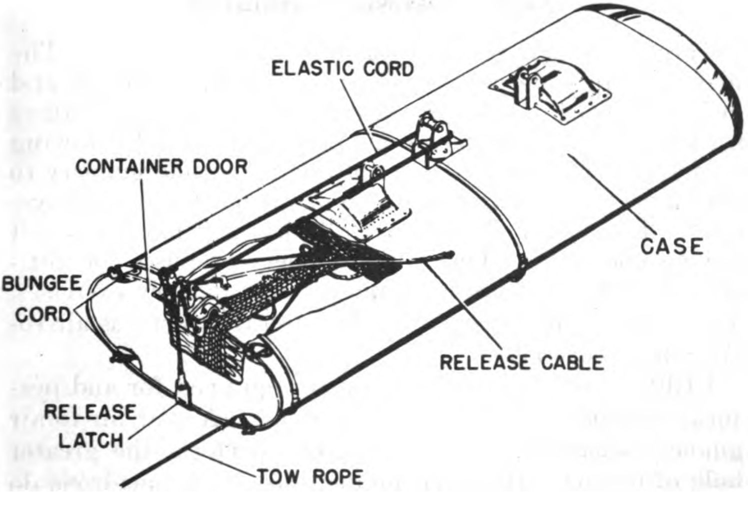


Figure 8–16.—Target Container Mk 1 Mod 2, packed with target and towline.

cient to reach from the target line release fixture on the towplane to the position at which the container door will be when hung from the bomb rack. Coil and secure this length so it will not be stowed in the container. Hold the container upright and fake all the line in figure "8's" into the container. Be sure the bungee cord ejector is unhooked and out of the way.

Replace the bungee cord ejector so that it forms an "X" and lead both ends of the towline out through the same opening in the "X." Insert the target into the container on top of the bungee cord ejector. Close and latch the container door. Tie the latch with light breaking cord to prevent accidental opening. The loaded container is now attached to the bomb rack. Adjust the sway-braces properly to support the container.

Check all installation work thoroughly. Test the operation of the container by simulating the release of the target. Do not touch the container or components thereof while making this test. However, stop the container door as it flies open to prevent the target from being discharged. Close the door again and secure it with light breaking cord. This will prevent accidental opening during takeoff of the towplane.

TARGET TOWING TECHNIQUES

Target towing in the Navy has two major objectives. The first is to provide gunnery training for the offensive and defensive arms of the fleet against enemy airborne targets such as aircraft and guided missiles. The second is towing accomplished in connection with proving ground gunnery to determine the comparative worth of various fire control systems. Two broad classes cover all phases of naval aircraft towing operations. One is the gunnery exercises for antiaircraft batteries known as antiaircraft gunnery exercises. The other is gunnery exercises for aircraft known as air-to-air gunnery exercises.

Utility squadrons of the Navy are equipped for and perform towing services for both antiaircraft and air-to-air gunnery exercises. These squadrons perform the greater bulk of towing. However, fighter and attack squadrons do their own towing for air-to-air exercises much of the time, as the services of the utility squadrons are not sufficient to meet all demands. Occasionally FASRons will aid in the towing for air-to-air practices.

Towing is not new to the Navy. For almost 30 years the Navy has been developing new towplanes, targets, and the equipment used with them. During 1946, cognizance of the target towing program was shifted from the Bureau of Ordnance to the Bureau of Aeronautics. This was a natural decision. Development and research, cognizance over all towing operations, and logistical support seemed to naturally fall under the direction of a single Bureau.

Towing at ever increasing airspeeds has necessitated the production of more powerful target reels, targets of much cleaner design, and allied equipment to withstand the stresses set up by increased airspeeds. Realism has been added to air-to-air and antiaircraft gunnery practices with the advent of the winged target. These targets not only look very much like an aircraft, but they may be towed much faster than the banner and sleeve targets, and they closely simulate the actions of the towplane in making banked turns.

Target towing for antiaircraft gunnery exercises is conducted for the practice of both the forces afloat and the shore based units. All types of automatic weapons are fired in these practices. For the smaller automatic weapons (.50 cal., 20-mm, and 40-mm) from 3,500 to 4,000 feet of towline is employed. For all larger caliber guns at least 7,000 feet of towline must be used. These are the minimum towline lengths used in this work. Towlines must be at least 900 feet long in towing for air-to-air gunnery exercises in which fixed and free guns are used. When the towplane is equipped with a tow reel, a minimum of 2,000 feet of towline must be used for air-to-air exercise. See NAVAER 00-80T-35 for techniques of towing aerial targets.

Towing Combinations

All aircraft towing operations have been placed ARBITRARILY into four categories in this section. This has been done for clarity in describing the combinations of aircraft, target, equipment, and personnel involved in the various towing operations. These categories will be called TOW COMBINATIONS. Table 8-2 shows the details of the four combinations.

Table 8–2.—Tow Combinations.

Tow combinations	Distinguishing characteristics	Personnel involved	Tow aircraft	Targets used
1	Reel-equipped aircraft employing manual launchings.	Pilot. Tow reel operator. Safety towman.	Utility tow aircraft or combat aircraft equipped with quick-demountable reel.	Sleeve-type. Banner-type.
2	Reel-equipped aircraft employing drag takeoff.	Pilot. Tow reel operator. Safety towman. Ground crew.	Utility tow aircraft or combat aircraft equipped with quick-demountable reel.	Winged-type.
3	Aircraft with target release fixture employing target container or target carrier launcher.	Pilot. Ground crew.	Fighter- or attack-type combat aircraft.	Sleeve-type or banner-type.
4	Aircraft with target release fixture employing drag take-off.	Pilot. Ground crew.	Fighter- or attack-type combat aircraft.	Banner-type or winged-type.

Tow combination 1.—The targets (either banner or sleeve) are launched from the towing aircraft, and may be used either for air-to-air or antiaircraft gunnery practice. If the towing aircraft is a utility plane, more than one reel is usually carried. Combat aircraft make use of the quick-demountable reel for these practices. All personnel involved are briefed prior to the flight in order to establish the procedures for the mission, and to minimize the amount of communications necessary in the air. The pilot uses the standard launching procedure by entering a shallow climbing turn at the optimum airspeed just prior to launching the target. The target is then launched by the tow reel operator (and safety towman, if utility plane is being used) from the tow compartment, and practice is begun. Damaged targets may be replaced in the air by sending a new target down the towline on a messenger. The releasing device used at the end of the towline is tripped by the ring of the messenger. This action releases the old target and the new one slides into the catch on the end of the releasing device.

In the event that the releasing device and the target are both shot off, a snarl catcher may be sent down the towline with a new target attached by a target leader. The snarl catcher clamps onto the towline as it reaches the first obstruction, or snarl. The target then streams automatically. The snarl catcher is not used extensively these days as high-speed reels are able to reel in the towline so quickly that little time is lost in putting on a new target. Often the snarl catcher (and target) will pass off the end of the towline as the snarls are straightened out by the catcher. At other times the snarl catcher will stop at the first snarl encountered. Thus, a lot of good towline is wasted, and a long whipping free end is left to endanger the firing plane. An iron horse has to be sent down the towline upon completion of the practice to clear the towline for reeling in. If the firing party desires to retrieve the used target, the pilot drops it over the designated recovery area.

Tow combination 2.—In this exercise a winged target is used. These targets are expensive. As a consequence, they are used mainly for air-to-air practice, and rarely for antiaircraft gunnery practice.

In making the drag takeoff the pilot taxis to the designated runway. The towline is attached to the aircraft by the ground crew, and the pilot taxis slowly forward until the desired amount of towline has been paid out from the reel. The ground crew steadies the winged target until the towplane starts its takeoff. The pilot climbs at the optimum speed and rate. The target will skid along the runway until the towline is almost vertical. The towplane actually lifts the target from the runway at this point. The winged target is designed with a negative angle of attack with respect to its longitudinal axis and the skid. It is also designed nose-heavy in trim. This is purposely done to give the target better towing characteristics and aerodynamic stability while taking off and while airborne.

If the winged target is damaged badly during practice and proves to be a burden to tow or becomes erratic in flight, the tow reel operator will most likely cut it off by sending an iron horse down the towline. He may then stream a sleeve target by reeling in or sending a snarl catcher down the towline, as the circumstances dictate. Most winged targets have a device incorporated which automatically releases the cable from the target when the skid touches the runway. After the firing runs are complete, the pilot returns to the field and lands the target on the runway. His approach to the runway is long, straight, and as slow as safety will permit. During this approach he lines up the target with the runway. The pilot should be in communication with the tower or a radio truck stationed near the runway. He will not be able to see the target in most instances and should be "talked down" by the tower personnel or radio truck crew to insure that the target lands on the runway. During takeoffs and landings the winged target should be reeled in as near the towing aircraft as possible. It is much easier to control the actions of the target in this position. If the towplane is a jet, the target should be reeled in preferably to within 75 feet and not more than 150 feet. The shorter tow length will lessen the effect of the jet blast on the target. The towplane normally makes another approach and lands on the runway after the ground crew has retrieved the target.

TOW COMBINATION 3.—In this combination the air-to-air exercise is employed. The towline is equipped with a releasing device, and either a banner or sleeve target is used. A target CARRIER is attached to the towplane if the banner target is to be used. A target CONTAINER is attached if a sleeve target is to be towed. A fixed length of line is used to tow each type of target.

The pilot takes off and rendezvous with the firing party over the firing area. He makes the normal shallow climbing turn and releases the target by pulling the manual bomb release if a container with sleeve target is used. If a carrier with banner target attached is used, the electric bomb release is pressed. After the practice is completed, the pilot returns to the designated recovery area with a guard plane. It is the final responsibility of the guard plane pilot to insure that the target is released at the recovery area at the correct moment. If the target release fails to operate on the dropping run, the guard pilot immediately notifies the towplane pilot, and another pass is made. The ground crew retrieves the target.

TOW COMBINATION 4.—THIS COMBINATION IS EMPLOYED FOR AIR-TO-AIR GUNNERY EXERCISES ONLY WHEN TARGET CONTAINERS AND CARRIERS ARE NOT AVAILABLE TO THE TOWING ACTIVITY.

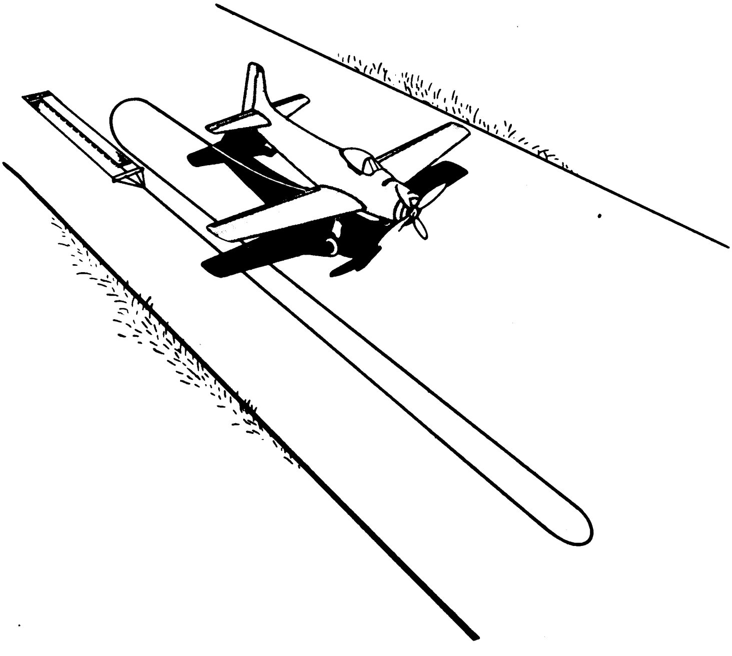


Figure 8–17.—Typical positioning of target and towline for drag takeoff.

The launching of the target necessitates the use of the drag takeoff. This takeoff is both damaging to the target and dangerous for the pilot. The pilot has to climb as rapidly as possible to get the target off the runway before it is damaged and to have sufficient altitude to clear all obstacles at the end of the runway. The resulting climb is dangerously steep, and the airspeed is only a few knots above stalling when the slack in the towline runs out and the target adds its weight and drag to the tow. Flying skill and experience are necessary at this point to successfully complete the launching.

The pilot taxis out to the designated runway. The ground crew attaches the ring of the towline to the target release fixture and checks its releasing operation with the cooperation of the pilot. The ground crew has previously laid out the towline as shown in figure 8–17. Upon completion of the exercise the pilot returns to the recovery area with the guard plane and drops the target to the waiting ground crew. He then continues the flight for another approach and lands. His first (dropping) approach is necessarily high as the 900 feet of towline causes the target to stream much lower than the towplane itself. Winged targets may also be used in this combination. The procedures for launching, towing, and releasing the winged target have been given previously.

SAFETY PRECAUTIONS

There are a great many safety precautions associated with the target towing service. The more pertinent ones will be pointed out here.

It is essential that a TOW REEL OPERATOR and a SAFETY TOWMAN be assigned to each towplane having tow reels in a tow compartment. It is the duty of the safety towman to aid the tow reel operator, and to constantly check for incipient dangers while the tow reel operator is otherwise engaged.

Preservatives and lubricants may not be used on tow cables. High-speed reeling out generates heat caused by friction. This heat might generate explosive vapors from the lubricants in the tow compartment.

Cable should be uncoiled by standing the coil on its edge, holding the end, and unrolling the coil. Do not attempt to take cable from either a coil or roll by pulling the cable when the coil or roll are lying flat. The cable will snarl and kink.

When cutting nylon towline, the ends have to be bound or heat applied to the cut ends to melt the nylon to prevent raveling.

Safety tow webbing MUST be used between the target and the end of the towline. This webbing will prevent many of the fatal accidents caused by the pilot shooting off the towline and becoming entangled in the target. Multistrand safety webbings (100 feet long) will be supplied for use with banner targets.

The snarl catcher MUST NOT BE USED during air-to-air gunnery exercises. It may clamp on the towline before it reaches the end of the cable. This means that there will be a long free section of the cable whipping about behind the target.

All personnel involved in target towing operations must know the standard hand signals for controlling aircraft on the ground.

Perform a preflight inspection of all tow equipment.

Keep wire cutters ready for instant use while towing.

Stand by tow reel brake while reeling out and reeling in.

Make sure you are clear of cable when launching target.

There are many do's and don'ts for the pilot, tow reel operator, safety towman, ground crew, and others involved in target towing missions. They are all common sense items, and have been prepared as a result of bitter experiences. They must be learned thoroughly by all concerned. Each squadron or unit conducting towing operations has its own set of safety precautions and regulations, and its own set of tricks of the trade which, if observed, will greatly reduce the hazards of towing and insure smooth operation of the mission. Learn these completely before engaging in any part of the operations.

QUIZ

1. The basic types of targets are the
   a. antiaircraft, aircraft, banner
   b. sleeve, banner, antiaircraft
   c. banner, sleeve, winged
   d. banner, sleeve, truncated cone

2. To rig a banner target for horizontal flight, the counterweight is attached to the
   a. center of the spreader bar
   b. bridle lines
   c. end of the spreader bar
   d. bridle eye

3. The Swept-Wing Target Aero 27A is normally released by a/an
   a. Cable Cutting Messenger Mk 7
   b. cable cutters
   c. automatic bridle release mechanism
   d. Release Messenger Aero 10A

4. The most flexible method of towing aerial targets is obtained by the use of
   a. tow reels
   b. target containers
   c. target carriers
   d. drag takeoff

5. The part of the Mk 8 tow reel which helps prevent backlash is the
   a. freewheeling assembly
   b. clutch assembly
   c. drive assembly
   d. level-wind assembly

6. When the clutch of the Mk 8 tow reel is engaged, the drum will rotate with the shaft in the
   a. rewind or unwind direction
   b. rewind direction only
   c. unwind direction only
   d. direction selected

7. When reeling cable OUT from a Mk 8 tow reel the
   a. brake is locked
   b. clutch is engaged
   c. clutch controls the speed
   d. brake controls the speed

8. When reeling cable IN, the rotation of the drum of the Mk 8 tow reel is stopped by the
    a. clutch
    b. brake
    c. speed control valve
    d. freewheeling assembly

9. Lubrication on a tow cable which is being reeled out will
    a. preserve the cable
    b. cause the cable to run smoothly
    c. prevent overheating
    d. create a fire hazard

10. Towlines are used for
    a. reel and container towing
    b. drag and container towing
    c. reel and drag towing
    d. drag towing only

11. When exchanging a target, the release trigger of the Target Release Mk 7 Mod 3 is forced aft by the
    a. release ring
    b. next target launched
    c. release trigger spring
    d. latch pivot

12. A target is connected to the snarl catcher with a/an
    a. quick eye splice
    b. knot
    c. target leader
    d. "U" shackle

13. The "Chicago" grip provides a means of transferring the target drag load from the reel to a/an
    a. target release fixture
    b. structural member of the plane
    c. bridle eye of the target
    d. outrigger assembly

14. Safety tow webbing is used
    a. for antiaircraft gunnery
    b. to prevent damage to the towplane
    c. because it is stronger than tow cable
    d. to insure the safety of the pilot firing at the target

15. To release a target held by a Snarl Catcher Aero 1A you would use a/an
    a. Release Messenger Aero 10A
    b. different target
    c. cable cutter
    d. Cable Cutting Messenger Mk 7

16. The launching of a target from an Aero 1A banner target carrier is accomplished by operating the
    a. manual bomb release
    b. electric bomb release
    c. container door latch
    d. target release fixture

17. For container type towing the release ring is attached to a/an
    a. bomb rack
    b. aircraft tow release
    c. target container
    d. 100 feet of safety webbing

18. The type of squadron most likely to be employed for antiaircraft practice would be a/an
    a. fighter squadron
    b. patrol squadron
    c. attack squadron
    d. utility squadron

19. The use of carriers or containers is preferred over drag towing because
    a. they are easy to pack
    b. it is a safer method of towing
    c. electrical operation is dependable
    d. the dropping approach may be lower

20. A snarl catcher must not be used during air-to-air gunnery because
    a. it cannot be used with towline
    b. it may pass over the snarl
    c. high-speed tow reels cut reeling-in time
    d. there may be cable whipping aft of the target

21. For all guns larger than 40-mm the minimum length of tow cable used is
    a. 7,000 feet
    b. 3,500 feet
    c. 1,500 feet
    d. 12,000 feet

22. In a loaded Mk 1 Mod 2 target container, the target is located between the
    a. suspension hooks and door
    b. line and safety tow webbing
    c. bungee cord ejector and door
    d. tow target release and container

23. It is essential that a plane having tow reels have assigned in the tow compartment a/an
    a. tow reel operator and radioman
    b. radioman and ordnanceman
    c. ordnanceman and radar operator
    d. tow reel operator and safety towman

CHAPTER 9

SUSPENSION AND RELEASING EQUIPMENT

During the early days of combat aircraft, small bombs were sometimes taken along in the cockpit and thrown over the side into enemy positions. They were only as effective as the BOMBARDIER'S SENSE OF TIMING and SEAMAN'S EYES. Sheer luck obviously played a great part in any actual hits or near hits made by this system. As larger aircraft bombs were developed, devices had to be produced which were capable of carrying and releasing them. These devices were designed to release the stores carried without delay, and to operate safely at all times. Present day suspension, releasing, and arming devices have grown out of this early need for carrying munitions to the enemy.

The devices described in this chapter are all parts of the armament system of the aircraft. They are generally operated by electricity, and are therefore placed in the aircraft's electrical circuits. They are actuated at the instant desired either by hand switch or automatically through some circuit closing device in the system. Provisions are also made to operate them manually if the necessity arises.

Before World War II, the Bureau of Ordnance was responsible for all suspension, arming, and releasing devices used by the air arm of the Navy. During the war this responsibility was shifted to the Bureau of Aeronautics.

Aircraft bombs, torpedoes, rockets, mines, and fuel or chemical tanks are suspended either internally or externally from the aircraft. Bomb racks, shackles, and combination bomb racks and rocket launchers perform this duty. The function of these devices is to carry, arm, and release these stores. The racks are usually bolted to the wings, or fuselage, or placed in the bomb bay of the aircraft. Shackles are generally suspended from internal guide rails by utilizing pivoting supports. Normally, the bomb rack has its own arming and releasing unit integral with the rack. These units are operated remotely by electrical impulse or a manual release. Shackles are usually dependent on an attached unit, or units, to arm and release their stores. The combination bomb racks and rocket launchers are usually attached to the underside of the aircraft's wings, and are actuated through an electrical circuit or manually from the cockpit. The shape, size, and weight of the stores carried has dictated the design of the devices. They have all been strengthened to withstand the presently greater loads imposed on them. These loads result from increased weights of the stores as well as the increased "g-load" (accelerations of gravity) factors introduced by the modern high-speed aircraft. High-tensile steels are being used in the manufacture of these devices to meet the needs of greater strength.

Gravity is the force normally depended upon to insure that the store clears the aircraft when released. However, a powder charge is sometimes used to "kick" the store clear of the aircraft. When the store is released from an aircraft in a dive, it is necessary to aid gravity with an additional kick to insure that the store clears the propeller and other parts of the plane. These devices are actuated electrically, and are called EJECTORS.

Refinements to suspension, arming, and releasing devices for aircraft have brought about development of associated electrical gear. There are intervalometers to time the release of bombs. There are rack selectors to control the pattern of bomb releases. There are other units which preselect the desired arming of bomb fuzes, and establish definite order and grouping of rockets fired. Each serves a definite purpose in accurately delivering stores to the enemy.

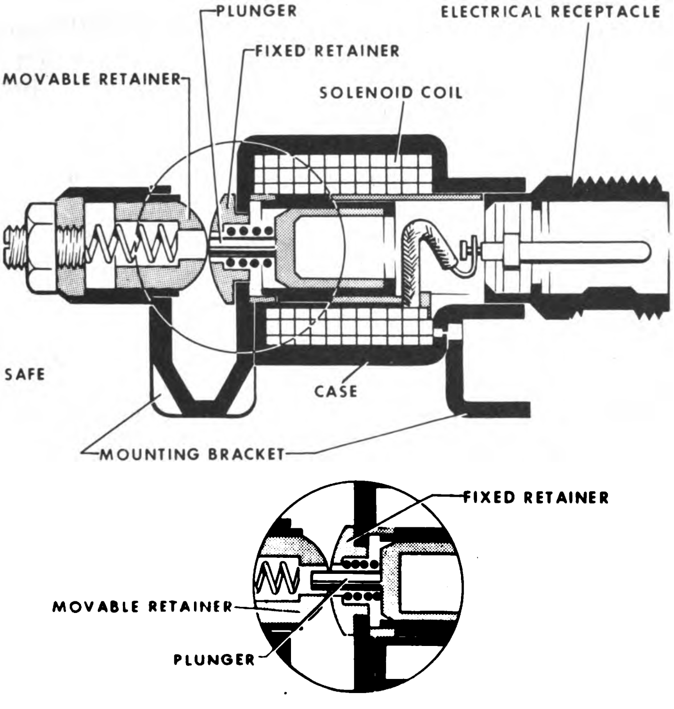
COMPONENTS OF AIRCRAFT ARMAMENT

Aircraft Bomb Arming Control Type AN-A-2

DESCRIPTION.—The bomb arming control Type AN-A-2 is an electrically operated locking device. It is designed to provide selective arming of bombs. Each control is constructed so that it will retain or release a fuze arming wire as the bomb is released. The bomb will then drop in an armed or safe condition as desired. One or more of these bomb arming controls is used at each bomb station in the aircraft. The number used will depend on the type of bomb shackles and bombs.

The AN–A–2A is an improved design completely interchangeable with the AN–A–2. The differences are entirely internal to improve reliability of operation.

Operation.—The electrical circuit of the bomb arming control AN–A–2 is separate from the aircraft's bomb release system. These arming controls are connected in parallel and are operated by one arming switch. More arming switches may be used in varying the grouping of the arming controls if desired. The bomb arming control is designed as a dust-tight, moistureproof, cadmium plated unit weighing about five ounces. It contains a solenoid coil, plunger, and movable retainer. (See fig. 9–1.) The movable retainer, being spring-



SAFE

ARMED

Figure 9–1.—Bomb Arming Control Type AN–A–2.

loaded, is held against the fixed retainer by spring action. The loop of the fuze arming wire is placed between the movable and fixed retainers. The force necessary to free the arming wire loop from between the retainers when the arming control is DE-ENERGIZED is normally adjusted from 3 to 5 pounds. The movable retainer and the plunger act together to retain the loop of the fuze arming wire. When in the locked position (arming control ENERGIZED), the plunger prevents the arming wire loop being dislodged from the arming control, thus causing the arming wire to be pulled from the fuze, arming the device after the bomb is released.

The AN–A–2 bomb arming control is locked by the energizing of the solenoid coil. This moves the plunger outward into the hole in the movable retainer. (See fig. 9–1, insert showing armed condition.) The control will remain in the locked position as long as the solenoid coil is energized. The bomb arming control will operate normally in temperatures varying from minus 70 to plus 200 degrees Fahrenheit.

SAFETY PRECAUTIONS.—The plunger and plunger stop of the AN–A–2 arming control should be washed and cleaned periodically to remove salt and other foreign matter which may prevent the plunger from operating properly.

When installing this arming control, insure that the mounting screws make a positive grounding circuit between the control and the mounting surface. Also insure that the control is mounted so that the pull on the fuze arming wire loop is as near to 90 degrees to the longitudinal axis of the plunger and the movable retainer as possible. If the angle of this pull is too far off from 90 degrees, it may be impossible to drop the bomb stores in a SAFE condition as the fuze arming wires will not pull free from the arming control, but remain in the control.

Aircraft Mk 8 Bomb Shackle

DESCRIPTION.—The Mk 8 bomb shackle can carry and release any Navy or Army-Navy bomb store weighing from 100 to 2,240 pounds. (See fig. 9–2.) It is also designed to carry and release aerial torpedoes. The Mk 8 may be used for either horizontal or dive bombing. It may be operated either manually or electrically. Electrical releasing is accomplished by attaching the Mk 1 bomb shackle release or

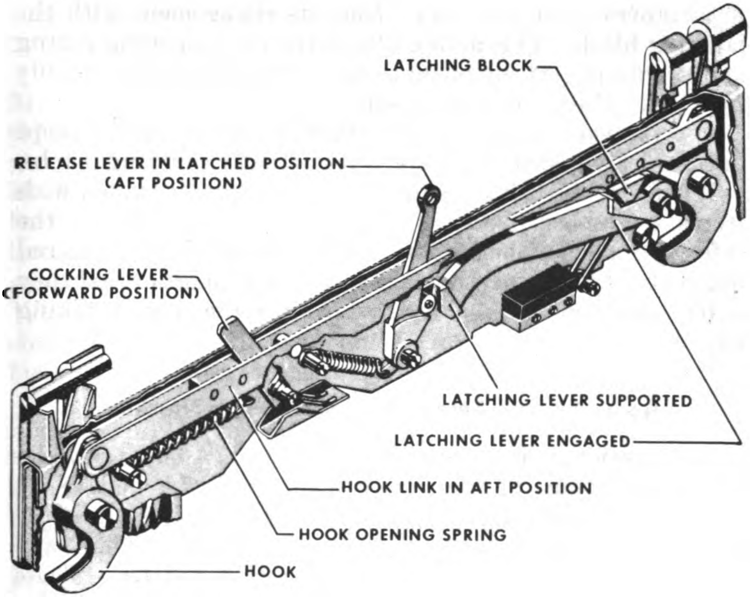

LATCHING BLOCK
RELEASE LEVER IN LATCHED POSITION (AFT POSITION)
COCKING LEVER (FORWARD POSITION)
LATCHING LEVER SUPPORTED
LATCHING LEVER ENGAGED
HOOK LINK IN AFT POSITION
HOOK OPENING SPRING
HOOK

Figure 9–2.—Cutaway view showing Mk 8 shackle in latched position.

the Aero 4A or 4B bomb shackle release to the Mk 8 shackle.

The frame of the Mk 8 shackle is an inverted **U**-shaped member. The frame suspension lugs are also **U**-shaped. They are attached to the ends of the frame by pivot bolts which also retain the hook link assembly in place within the frame. Other components of the Mk 8 shackle are the cocking lever, release lever, latching lever, and associated springs.

There is only a single difference between the Mk 8 Mod 0 and the Mk 8 Mod 1 bomb shackle. The Mod 1 shackle has had $\frac{1}{16}$ inch removed from the rear of each hook. The Mod 0 could not be used in certain aircraft due to the fact that the aft carrying hook protruded $\frac{1}{16}$ inch beyond the shackle frame when the shackle was released.

Operation.—In cocking the Mk 8 shackle, the cocking lever is moved aft until the latching block on the link assembly engages in the slot of the latching lever. The roller on the latching lever rides up and seats on the top of the release lever cam. When the release lever is moved forward (either by the Mk 1 bomb shackle release or manually) the latching lever moves down and away from its engagement with the latching block. This action allows the hook opening spring and the weight of the bomb to move the hook link assembly forward. The bomb is then released.

SPECIAL PRECAUTIONS.—The Mk 8 shackle should be kept in the released position except when actually carrying bombs.

When work is being performed on an aircraft loaded with stores, a number five safety pin should be inserted in the safety pin hole of the shackle. Suitable signals (such as red flags) should be attached to the safety pins in order that they will be seen and the pins removed prior to the aircraft taking off.

Aero 16A and Aero 17A Aircraft Bomb Shackles

DESCRIPTION.—The Aero 16A and Aero 17A bomb shackles are modifications of the USAF shackles D–7A and D–6A respectively. The D–7A and D–6A were widely used by the Navy along with a bomb shackle release unit. The Navy modified these shackles by adding two adapter plates. These plates support a bomb release unit (Mk 1 Mod 4) and its mount. They are bolted and clamped to the forward end of the frame assembly. The Aero 16A is designed to carry a 4,000-pound demolition bomb; the Aero 17A, a 2,000-pound demolition bomb. These shackles consist of a frame assembly, link assembly, bomb release adapter plates, and an arming assembly. The frames are of stainless steel and are spot-welded to an upper and lower channel for added strength. The link assembly (1) consists of two forged hooks permanently riveted to two links of stainless steel. (See fig. 9–3.) The carying hooks (9) are located at the ends of the links. The bomb release adapter plates are fastened around the frame assembly with machine screws on the lower end, and a clamp type arrangement on the upper end. This assembly is used to support the Mk 1 Mod 4 bomb release unit and its mount. An adapter has also been included on the Aero 16A shackle to support the Aero 4A or Aero 4B bomb shackle release.

The lugs of the bomb store will CLOSE the hooks of the Aero 16A and 17A shackles as it is lifted into position on the shackle. However, although the hooks will appear to be locked, it is necessary to manually push the release lever (4) (fig. 9–3) towards the arming lever (5) and allow it to return before the bomb store is actually LOCKED to the shackle.

OPERATION.—Electrical impulses received by the Mk 1 Mod 4, or Aero 4A or Aero 4B release units actuate the tripper hook (4). These devices release the bomb in either an ARMED or SAFE condition, as required. The tripper hook has two positions: LOCK and RELEASE. In the lock position the pawl (3) is held in the upper position by the hook. The pawl engages the pawl stop lug (2) on the link assembly. This prevents the opening of the carrying hooks. When the tripper hook is in the release position, the pawl is disengaged from the stop lug. The weight of the bomb is then sufficient to open the carrying hooks.

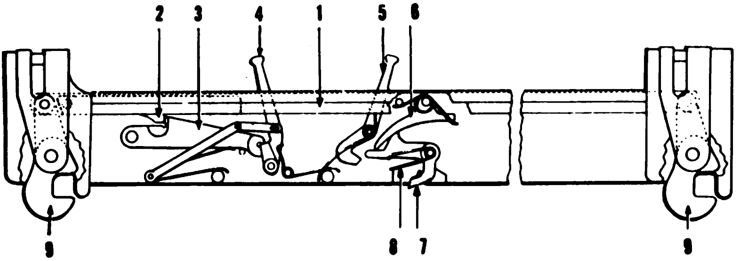


Figure 9–3.—Sectional view—Aero 16A and 17A shackle.

Also, the arming hook latch has two positions: SAFE and ARMED. With the latch in the safe position, the arming wire is held by the arming hook (7) by spring action from the arming hook spring (8). When the bomb is released, the link lever (6) applies pressure to the arming hook. This frees the arming wire. Thus the bomb is dropped safe. When the bomb falls with the arming hook in the armed position, the arming hook is locked. Thus the arming wire is pulled from the bomb fuzes. The bomb falls in the armed condition.

The arming hook latch (5) is not actuated automatically when the Mk 1 Mod 4, or Aero 4A or Aero 4B release units are installed on the Aero 16A and 17A shackles as they have no method of actuating it. Arming has to be performed by methods other than by use of the Mk 1 Mod 4, or Aero 4A or Aero 4B release units.

Bomb Shackle Release Mk 1 and Modifications

Description.—The Mk 1 bomb shackle release is an electrical device used to release bomb stores from the Mk 8 and Aero 16A and 17A bomb shackles. (See fig. 9–4.) This shackle release and its modifications are attached to the bomb shackle by the Mk 1 bomb shackle release mount. The various modifications of the Mk 1 release differ primarily in the types of connectors used, the methods of attachment to the release housing, and the length of their respective push rod arms. The bomb shackle release and its mount (Mk 1 Mod 0) may be fitted to either side of the Mk 8 shackle without modification other than reversing the assembly.

Operation.—The magnet coils of the release are energized by the electrical impulse received by the release. The magnet coils attract the latching armature. The movement of the latching armature about its pivot unlocks the release armature. The release armature is now attracted to the

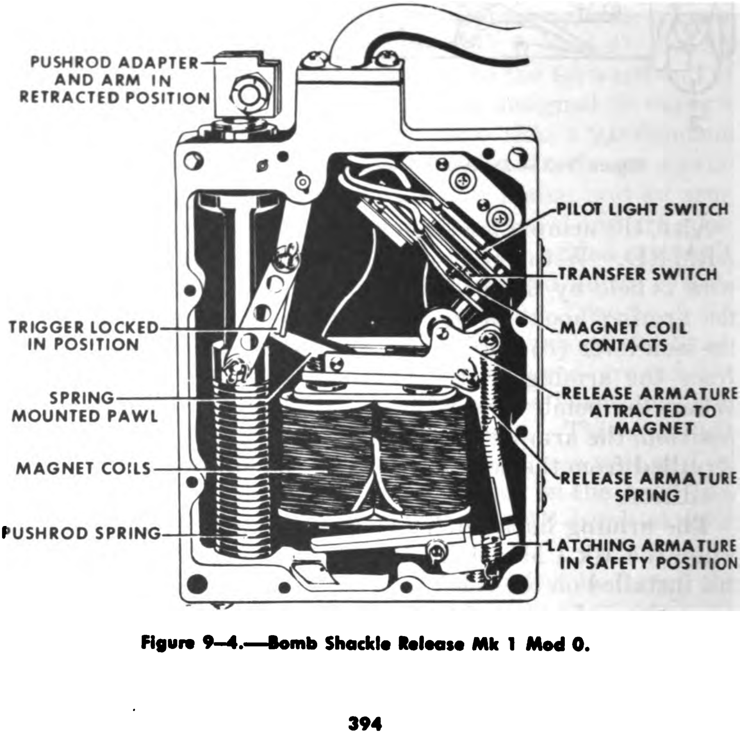

PUSHROD ADAPTER AND ARM IN RETRACTED POSITION
TRIGGER LOCKED IN POSITION
SPRING MOUNTED PAWL
MAGNET COILS
PUSHROD SPRING
PILOT LIGHT SWITCH
TRANSFER SWITCH
MAGNET COIL CONTACTS
RELEASE ARMATURE ATTRACTED TO MAGNET
RELEASE ARMATURE SPRING
LATCHING ARMATURE IN SAFETY POSITION

Figure 9–4.—Bomb Shackle Release Mk 1 Mod 0.

other end of the magnet coils, causing the pawl to unseat the trigger. Unseating the trigger allows the push rod to move through its full limit of travel from the force of the push rod spring. The push rod adapter arm is connected to the release lever of the bomb shackle. Thus, as the push rod moves, it forces the release lever of the shackle to its release position, dropping the store.

As the electrical impulse ceases, the release armature moves away from the magnet coils from the force of the release armature spring. This movement causes the magnet coil switch contacts and pilot light switch contacts to open, and the transfer switch contacts to close. Opening the magnet coil switch contacts breaks the circuit to the magnet coils. Opening the pilot light switch contacts breaks the circuit to the bomb indicator light on the control panel. Closing the transfer switch contacts completes a circuit to the shackle release at the next bomb release station which is in series.

If vibration, or other outside force, tends to move the release armature toward the coils, the statically balanced latching armature assembly prevents this movement. Therefore, the trigger will not be freed and an inadvertent release of the store will not result.

Special precautions.—The Mk 1 shackle release should be kept in the released position except when the bomb shackle is loaded with a store.

Insure that the connector cable is secured to the receptacle in the aircraft, and that it is so arranged that it cannot become fouled in the structure of the plane or hamper the release of the suspended store.

Aircraft Bomb Shackle Releases Aero 4A and Aero 4B

Description.—The Aero 4A and 4B bomb shackle releases consist of three major assemblies. (See fig. 9–5.) These are the release assembly (1), the transfer unit assembly (2), and the mount assembly (3). These releases are basically an electrically operated spring-loaded plunger and sequence switch. They are equipped with a mounting clamp for attachment to a bomb shackle.

Cocking of the releases is accomplished by pushing in the plunger until it is held by an internal locking device. (See fig. 9–6.) The shaft is released electrically by a solenoid.

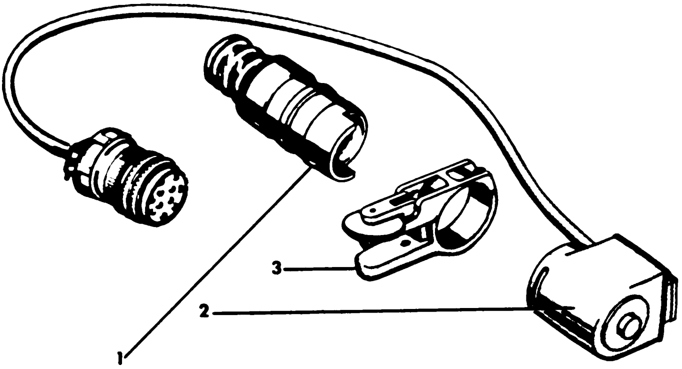


Figure 9–5.—Major assemblies of the Aero 4A and Aero 4B bomb shackle releases.

A control relay and switching assembly in the unit operate an indicator light and transfer circuit. The Aero 4 releases provide electrical releasing for the Mk 8, Aero 16, Aero 17, and other similar shackles. The releasing assembly contains a coil and shell assembly (1), a plunger assembly (2), plus a forward ring (3), an end cap (4), and a boot. The coil and shell assembly is composed of a release solenoid and necessary electrical contacts which are housed in the shell. The plunger assembly consists of a machined guide tube, six chrome steel locking balls, two circular spring-loaded armatures, grooved plunger shaft, aft cap, washer, O-ring, primary and secondary actuating springs, plunger head, and the contact plunger.

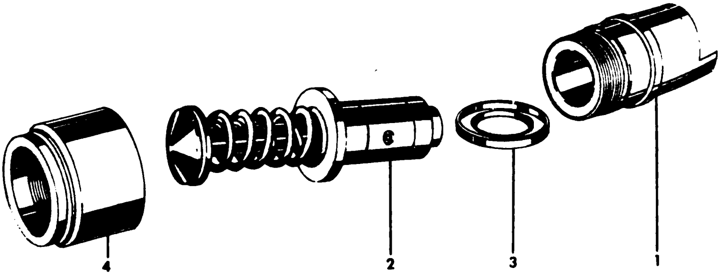


Figure 9–6.—Release assembly, Aero 4A and Aero 4B bomb shackle releases.

The transfer unit assembly (2) (fig. 9–5) consists of a cage, a hinged armature and coil assembly, one contact arm, fixed and movable contacts, and required insulators, bushings, spacers, and wiring. The mount assembly for adapting the Aero 4A or 4B release to the Mk 8 bomb shackle consists of a split type clamp, a spring-loaded locking pin, and a lock retainer. The mount assembly for adapting the Aero 4A or 4B to the Aero 16 and Aero 17 shackle consists of a split type clamp with an integral adapter attachment fitting. It also has a spring-loaded latch for quick change service.

Operation.—Operation of the Aero 4A or 4B bomb shackle releases is effected by an electrically controlled spring-actuated plunger. Control is offered by a solenoid and a holding relay which operates three switch circuits. The incoming impulse energizes the solenoid and the holding relay. This is done by a power lead and a single-pole, double-throw (SPDT) transfer switch. The indicator light switch is held closed by pressure of the plunger cap on the transfer switch armature lever arm. Energizing the solenoid pulls the two plunger armatures into the plunger core releasing ball locks and the spring-loaded plunger. Actuation of the plunger withdraws the contact plunger from the contact fingers. This releases the pressure on the armature lever arm. The solenoid series switch then de-energizes the solenoid. The holding relay remains energized for the duration of the electrical impulse, and holds the indicator light switch and the transfer switch in the firing position. Completion of the electrical impulse de-energizes the holding relay. This action releases the pole of the transfer switch from the firing contact to the transfer contact. At the completion of this action, the power circuit is closed through the transfer switch to the next bomb shackle release unit.

The only differences between the Aero 4A and the Aero 4B bomb shackle releases are the length of the respective pigtails and the design of the electrical receptacle. The Aero 4A has a 33-inch pigtail and the Aero 4B has a 6-inch pigtail.

Douglas Bomb Ejector Rack

Description.—The Douglas external stores ejector rack (fig. 9–7) is designed to carry stores up to 3,600 pounds with adapters, and 2,300 pounds with the 14-inch suspension con-

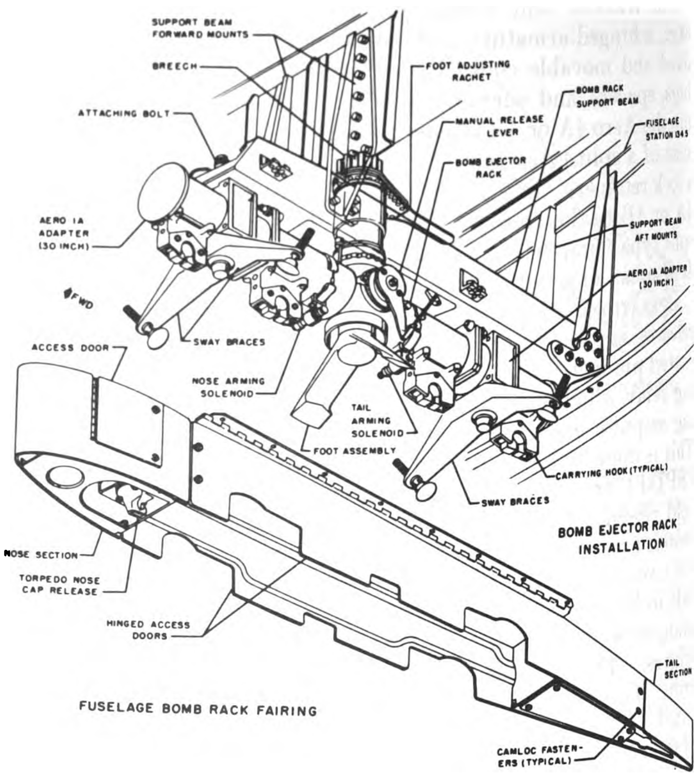


Figure 9–7.—Bomb ejector—fuselage bomb rack installation.

figuration. It is a combination bomb rack incorporating ejection, and is installed along the centerline of the fuselage. The ejector component of the rack extends in part inside the fuselage. The foot and suspension hooks project outside the fuselage. The ejector rack serves both as a support for the stores carried, and as a device for releasing them. It is fitted with two carrying hooks spaced 14 inches apart. However, an adapter is furnished which provides two extra hooks 30 inches apart for stores having the wider set of lugs. It is necessary to remove the ejector rack from the aircraft when installing this set of adapters.

Operation.—The ejector rack is electrically controlled. It is actuated by means of a 1-inch or 3-inch cartridge.

When the cartridge is fired, the gases between the foot assemblies and the piston expand. This moves the piston upward against the piston spring. The upper sleeve and release sleeve are moved upward at the same time. When the pressure in the cylinder reaches 82 p.s.i., the retainer plate mounted on the shoulder of the release sleeve has moved upward enough to release the carrying hooks through the action of the release linkage. The pressure continues to rise. The action then reverses its direction. All pressure is then exerted against the foot assembly forcing it downward with sufficient force to eject the store clear of the aircraft. After the foot is forced down, the gases escape through ports in the piston assembly. The piston spring then draws the foot back into the ejector. The foot acts as a sway brace for stores of 1,600 pounds and under. Auxiliary sway braces must be used on stores heavier than this. The store may be released manually if desired or found to be necessary. A cable operates the manual release lever to open the hooks and release the store. The store may not be released manually during dives steeper than 50 degrees without danger of the store striking the aircraft. The components of the Douglas ejector rack are a detonating breech, telescoping sleeves, and hooks and linkage. The piston and foot assemblies are centered above the store in the hooks.

The ejecting force employed by the Douglas ejector rack is the Mk 2 Mod 0 cartridge for stores weighing 325 pounds or less, and the Mk 1 Mod 2 cartridge for all the heavier stores. The Mk 2 Mod 0 cartridge is also used for stores that are delicate or have light cases, such as aircraft torpedoes and mines.

Special precautions.—Accumulated carbon on the piston and foot assemblies should be removed with cleaning fluid (70 percent acetone, 30 percent water) after each 20 shots of the ejector. The piston rings should be replaced after each 40 shots. After 60 shots, these assemblies should be disassembled and cleaned of all lubricant and carbon. Specified lubricants must be used during reassembly. When reassembling the piston and foot, a sealing paste is applied to the upper and lower threads. This paste is composed of equal parts of glycerin and litharge, and will harden one hour after mixing. Replace the O-rings when they show signs of deteriorating, or when the upper travel of the release sleeve and upper sleeve is in excess of the allowable maximum.

Combination Bomb Rack and Rocket Launcher Aero 14 Series

Description.—The Aero 14 series combination bomb rack and rocket launcher is a fixed pylon unit. It is designed to carry and launch 5-inch HVAR rockets. In addition it will carry and launch all 2-lug, 14-inch suspension stores up to and including 500 pounds. The Aero 14B is installed under the wing. It will release its stores in either a safe or armed condition. Toss bombing or conventional horizontal bombing may be conducted with the Aero 14B. This device will also carry and launch the subcaliber rockets if fitted with an Aero 1A adapter launcher. Five-inch motors with the 6.5-inch ATAR head may also be launched from the Aero 14B launcher.

The Aero 14B is attached to the wing by two hanger bolts and locknuts. Loosen hanger bolt locknuts before attempting to remove hanger bolt nuts. Tighten locknuts after securing hanger bolts.

It is cushioned against the wing by a rubber gasket (fig. 9–8 (A)). Forward and aft rocket supports are provided as are forward and aft bomb carrying hooks. The inner

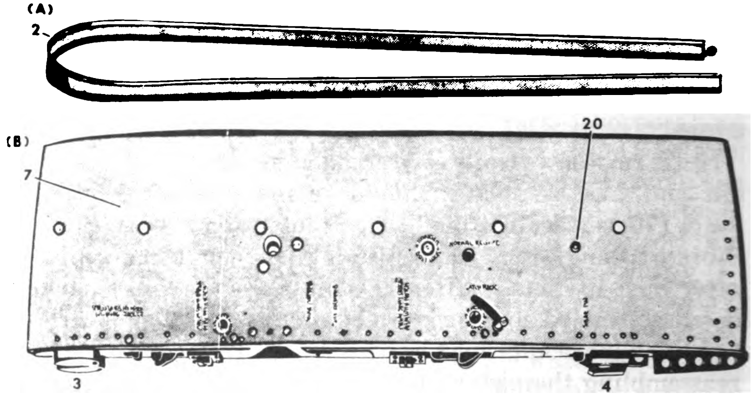


Figure 9–8.—Major assemblies, Aero 14B combination bomb rack and rocket launcher. (A) Rubber gasket; (B) fairing assembly.

components of the entire unit are enclosed in a streamlined fairing. There are two major assemblies in the Aero 14B. These are the fairing assembly (fig. 9–8 (B)) and the supports and bulkhead assembly (fig. 9–9). The supports and bulkhead assembly, in turn, consist of a rocket latch assembly and forward and aft support assemblies. These are connected by hook links and hook link springs. The upper bulkhead and electrical fitting assembly and the arming solenoid assembly complete the components of the supports and bulkhead assembly.

The end connector (1) of the rocket latch solenoid assembly screws into the main spring guide (2). (See fig. 9–9.) The main spring (3) and its guide fasten to the rocket latch solenoid and support assembly (4) by a sleeve (5). The rocket latch solenoid (6) screws into the rocket latch solenoid support. When the solenoid is not energized, the plunger protrudes into a hole in the guide. This prevents the guide from sliding. The plunger is retracted when the solenoid is energized. The guide is free to slide when the rocket latch is raised. If the solenoid or plunger does not operate, the shear pin in the end connector shears when the rocket thrust reaches about 1,500 pounds.

The forward and aft support assemblies (7) and (8) each carry a hanger bolt (9) and lock (10), sway brace assembly (11) and its adjusting worm (12), bomb hook (13), and stripper plate (14). Both hanger bolts protrude through the upper bulkhead (15). The rack release solenoid (16) and the sear assembly (17) attach to the aft support. The forward support carries the rocket firing contact arm (18). The brace arms (19) of each sway brace are pinned to the sway brace clevis (20). The sway brace clevis is threaded for the sway brace adjusting nut (22).

When the sway braces are pulled down, the adjusting nut engages the adjusting worm. Further turning of the nut tightens the arms against the bomb. As soon as the bomb is dropped, the sway brace return spring (23) pulls the brace assembly back into the fairing. The rocket firing contact arm is held to the stripper plates by the hollow shaft cast on the lower end of the arm. The other end of the arm carries the firing contact (24). It is insulated from the arm itself and connected to the electrical fitting.

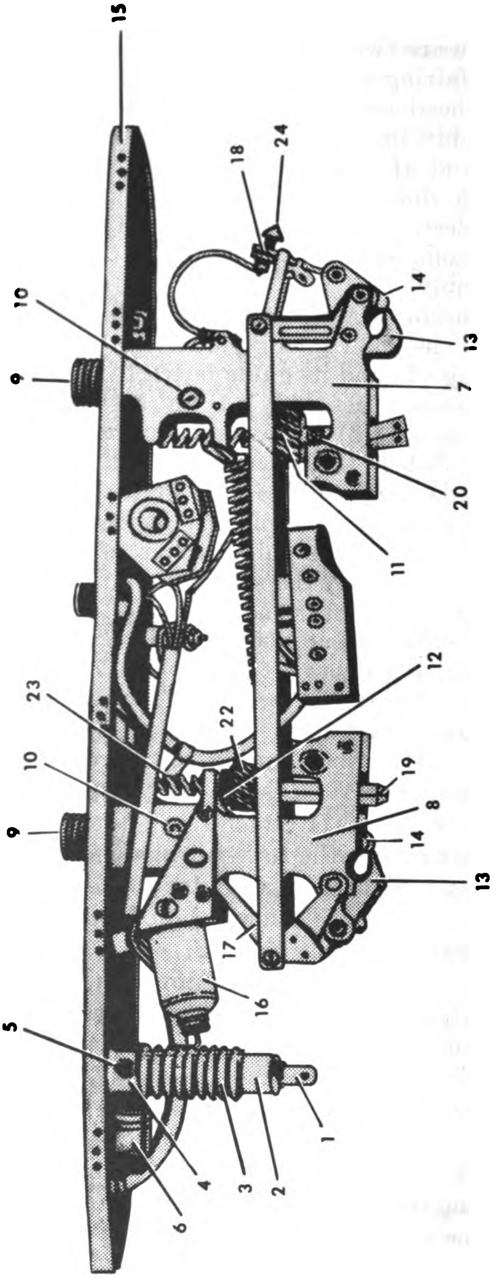


Figure 9–9.—Supports and bulkhead assembly.

The fairing of the Aero 14B has to be cut to fit the individual aircraft at the point of attachment. This is done with the aid of a scriber and two installation adapters. The adapters are screwed into the wing fittings. The rack and launcher combination is attached to these adapters. The scriber is then used to mark the fairing of the rack all around. The rack and adapters are removed. The fairing is cut along the scribed mark. The rubber gasket is fitted to the fairing, and the rack secured to the wing by the hanger bolts.

Operation.—When the rocket latch solenoid (1) is energized, the solenoid plunger assembly (2) retracts. (See fig. 9–10.) The guide (3) slides up when the rocket exerts the small amount of thrust necessary to raise the latch (4). This allows the rocket tunnel lug (5) to pass the latch.

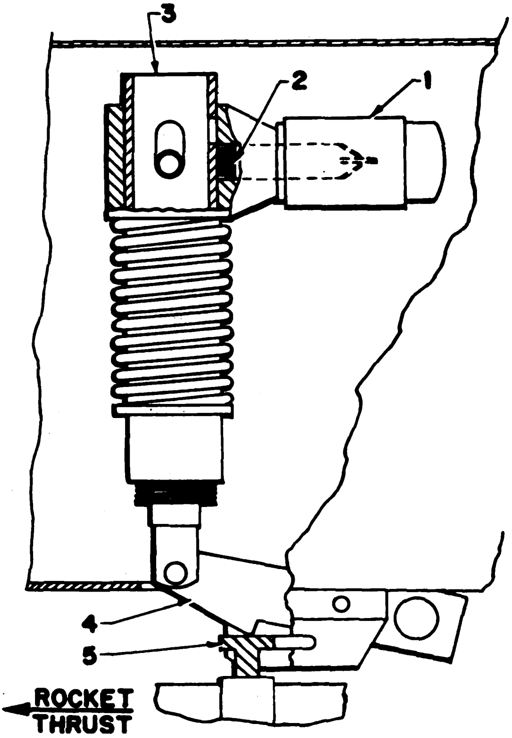


Figure 9–10.—Rocket latch released and raised.

A separate wing receptacle is used to connect the pigtail of the HVAR rocket to the firing circuit. When using the subcaliber rocket with the Aero 1A adapter, the firing voltage is supplied to the Aero 1A by operating the Aero 14B in the unlatched condition. This allows the rocket firing arm contact to remain in contact with the forward button lug of the Aero 1A.

The bomb locking device is operated by placing the operating lever in the hole (1) and rotating it counterclockwise in the Aero 14A. (See fig. 9–11.) On the Aero 14B the hooks are locked by pulling down on the rack latch arm. (See fig. 9–8 (B).) The Aero 14B differs from the Aero 14A in that the added hoist hook fitting is fastened to the fairing and upper bulkhead by bolts. The fairing access holes of the Aero 14B are modified by the addition of a rack latch slot, and the manual release hole relocated. The arm assembly (2) connects to the forward hook (5) by the rocket contact links (3), and to the aft hook through the hook links (4). A counterclockwise movement of these elements causes the carrying hook tips to move toward the stripper plates (8) and (9). This movement is against the tension of the hook springs (6). It continues until the roller bearing on the aft hook (7) is retained by the sear assembly (11). In the latched position the stripper plates and the hooks enclose the bomb lugs.

The solenoid push rod (13) is forced out of the solenoid when the rack release is energized. This lifts the sear assembly (11). The push rod is connected to the upper end of the sear. The hook springs then pull the tops of the hooks causing the carrying hook tips to move away from the stripper plates. This action releases the store. The store may be released manually on the ground by inserting the operating lever in the access hole (14) and turning it clockwise.

The arming unit action is the same for either rockets or bombs. It does not matter whether they are nose fuzing, tail fuzing, or both. Identical solenoids, operated from independent circuits, perform the arming functions. Arming is fully selective; that is, either the nose or tail or both the nose and tail may be selected at the same time for arming. The fuze arming wire loops are forced under the cone of the

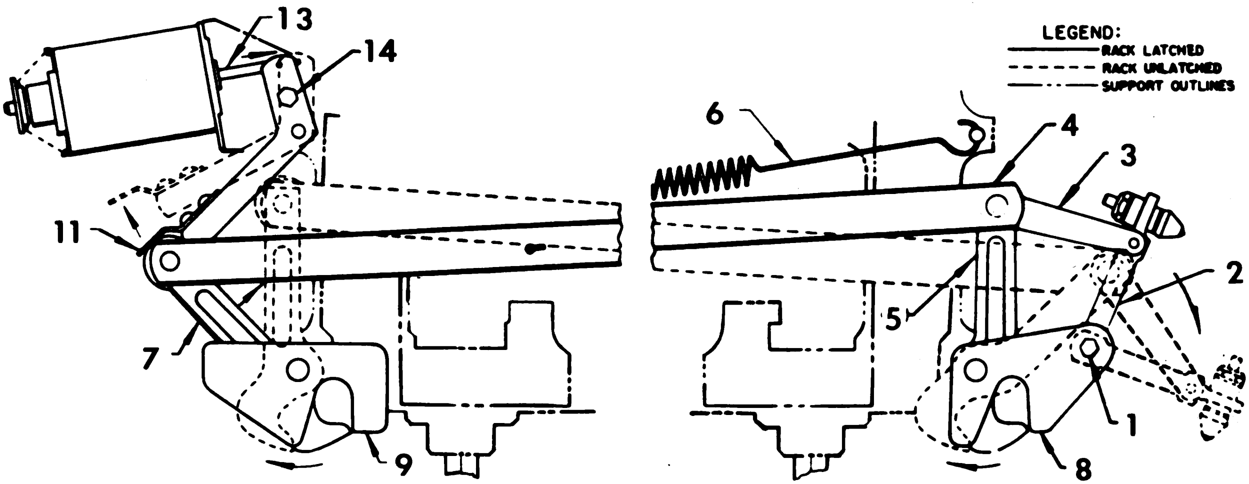


Figure 9–11.—Rack latch and release action.

arming unit where they are retained by spring action. The arming unit is not energized when a safe release is desired. Upon release, the wire or wires are easily pulled from the unit by the store. The spring action of the solenoid cone is not sufficient to retain the wire loop. The solenoid plunger locks the retaining cone when the store is to be released in the armed condition. Now the fuze arming wire cannot be pulled from under the plunger cone. This causes the wire to be retained by the cone, thus arming the store.

BOMB RACK AND ROCKET LAUNCHER

Aero 15A

The Aero 15A bomb rack and rocket launcher is similar to the 14 series. The 15A has a different method of sway bracing and the rocket receptacle is incorporated in the rack. It has double rocket striker arms, electric and manual fuzing and improved mechanical operation and emergency release. A hinged door provides easy access to the linkage.

Aircraft Mk 51 Bomb Racks

Description.—The Mk 51 aircraft bomb rack is designed to carry and release any mine, torpedo, or bomb up to a nominal weight of 2,240 pounds. Auxiliary fuel and chemical tanks may also be carried provided their suspension lugs are 14 inches apart.

Manual release of stores is effected by a wire cable leading to the cockpit. For electrical releasing, the rack is wired into the electrical system of the aircraft. The arming mechanism may be operated either electrically or manually. Actuation of the arming device securely locks the fuze arming wires in the rack arming wire retainers. Thus, the bomb arming wires are pulled from the fuzes and the bomb falls ARMED. If the arming devices are not actuated, the arming wires drop free of the arming wire retainers and stay in the fuzes. In this condition, the fuzes are prevented from arming.

The Mk 51 racks are designed for external mounting, either under the wings or on the fuselage of the aircraft. (See fig. 9–12.)

Operation.—The Mk 51 bomb rack is latched by lifting up

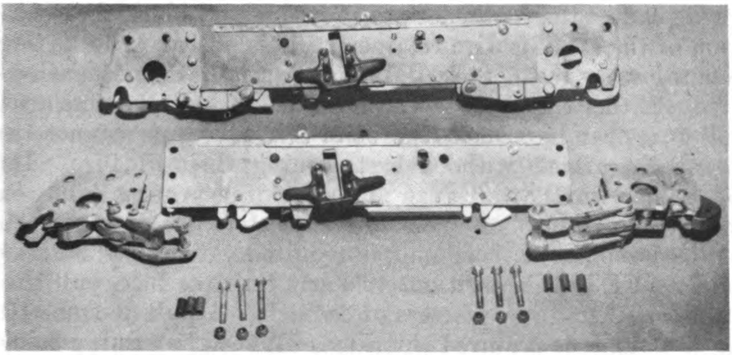


Figure 9–12.—Mk 51 bomb rack with 1A adapters.

on either of the two pawl latching pins (fig. 9–13). Lift until the release pawl engages the shoulder of the release lever. Manual releasing is accomplished by pulling the release cable a distance of about three-quarters of an inch. A pull of from 12 to 20 pounds is required. Electrical arming is fully selective. Energizing the arming solenoids will arm either the nose or tail fuzes, or both. Energizing the sole-

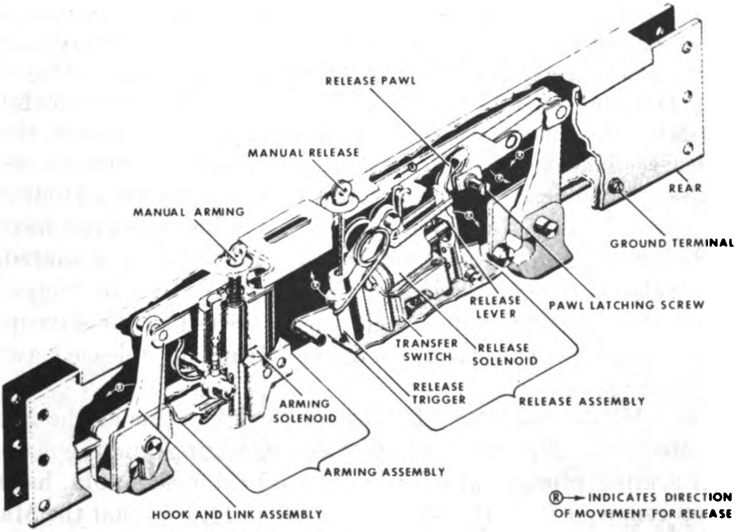


Figure 9–13.—Cutaway view of Bomb Rack Mk 51 Mod 11.

noids causes their plungers to protrude and block the rotation of the arming wire retainers. This positively locks the arming wires to the rack. Manual arming is only semiselective. Either the tail fuze can be armed or both the nose and tail fuzes can be armed together. The nose fuze cannot be manually armed without first arming the tail fuze. In order to arm the tail fuze manually, the arming cable is pulled a distance of about three-quarters of an inch. A pull of about 6 to 8 pounds is required. The nose fuze is still SAFE in this position. To arm the nose fuze, pull the cable another three-quarters of an inch. A pull of from 10 to 12 pounds is required this time. When the arming solenoids are not energized, and the arming cable is relaxed, both the nose and tail fuzes are in the SAFE condition.

Both the electrical and manual releases perform the same operation. They retract the release lever. This allows the release pawl of the hook and link assembly to drop, permitting the hooks to open. As the release pawl drops and rotates, the connecting link slides forward until the suspension hooks open and the bomb falls free. Rotation of the release pawl is caused partly by the action of the coil spring on the release pawl link and partly by the weight of the bomb. However, this spring will cause the hooks to open even though there is no bomb on the rack. When the release pawl has rotated down and the electrical impulse to the release solenoid ceases, a spring forces the release lever to pivot until the transfer switch actuating lever operates the transfer switch. Actuation of the transfer switch shunts out the release solenoid of the rack and bypasses any succeeding impulses to the next rack in the series. The transfer switch is provided in a single wire release system which does not have a distributing device. When the manual release is actuated, the release trigger rotates. The extension of the trigger pulls the release lever to which it is connected by the stirrup. The release lever is then disengaged from the release pawl and the hooks open.

The Mk 51 Mod 12 rack is essentially the same as the Mk 51 Mod 11. The transfer switch and its wiring, and the manual arming plunger and its spring and cable assembly, have been removed from the Mod 12. It then follows that the Mk 51 Mod 12 rack cannot be used in aircraft which require the use of a transfer switch. There are several features incorporated in the Mk 51 Mod 11 rack which do not exist in earlier modifications. Some of these are: release solenoids approximately twice as powerful as earlier models; arming solenoids more powerful and capable of continuous operation; pilot light switch not used in the Mod 11; arming assemblies made more positive for SAFE releases in all plane attitudes; hoisting brackets made stronger (support 2,240 pounds); release assembly easily removable for inspection without disassembly of the electrical receptacle; a quick-disconnect provided; major components made of corrosion resistant materials; and contour of suspension hooks modified to insure positive release of bombs in diving attitudes.

Special precautions.—The rack release mechanism should be kept in the release position except when actually carrying bombs.

Route all electrical cables, connectors, and arming wires so that they do not interfere with dropping the bomb.

Taper pins used to safety the rack when work is being done on the aircraft should have red flags attached to them. The flags serve as a warning to remove the pins prior to takeoff. The stores cannot be released if the pins remain in place.

If other than standard latching screws are used, the substitute must not extend into the threaded hole of the release link further than 3/16 inch. Otherwise, the rack will not release.

Nothing but the specified greases should be used on the plungers of the arming solenoids.

Insure that the release pawl engages the full width of the shoulder of the release lever when the rack is latched. The rack may release accidentally if only partial engagement is obtained.

The electrical release circuit must not be closed longer than

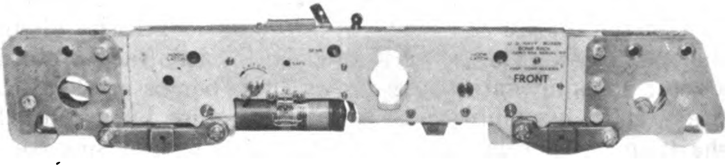


Figure 9–14.—Aero 65A Rack with Aero 4B release mounted and Aero 1A adapters attached.

absolutely necessary. The release heats up very rapidly and is likely to burn out if the circuit remains closed for more than 30 seconds.

Aero 65 Rack

The Aero 65 rack (fig. 9–14) is a replacement for the Mk 51 rack. Among the improvements incorporated in the rack are self latching hooks, electrical fuzing and greater strength.

Aircraft Bomb Container Type Aero 4B

DESCRIPTION.—The Aero 4B bomb container is a streamlined cylindrically shaped metal container. (See fig. 9–15.) It carries eight miniature practice bombs, Type AN–Mk 23. It is designed to be suspended from a bomb rack of either single or double suspension type. The bombs may be released either manually or electrically on the ground and electrically only while airborne. A predetermined number (up to the total load) may be released at a fixed rate if an intervalometer is placed in the electrical circuit. The container is designed for use with a double suspension type bomb rack. However, it may be converted to suspend from a single lug type rack by removing a plate and attaching a center suspension lug that is provided. The Aero 4B is fitted with two suspension lugs and an electric cable on its top side. The bottom has two open bays through which the practice bombs are loaded and released. A safety latch and a manual release (centered flush in the nose fairing) are the other two external features.

The inside mechanisms of the Aero 4B are divided into four sections. These are the nose, the forward bay, the rear bay, and the tail section. In the nose is a release solenoid, a latching device, and a manual release rod. These devices control the release shaft which is located lengthwise along the open bays. The forward and rear sections each contain a rotor assembly into which the practice bombs are loaded. These rotor assemblies are fastened together by a central shaft, and work together as one unit. The tail housing contains the power spring and a ratchet system for indexing the rotors during loading. The entire container may be

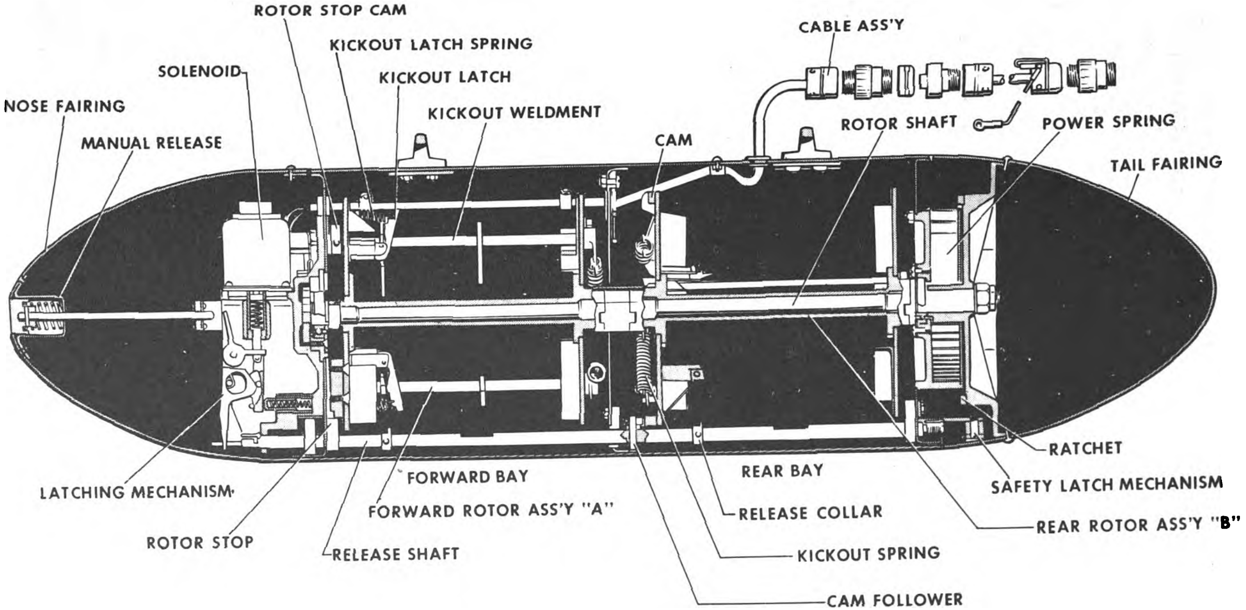


Figure 9–15.—Cutaway and sectional view—Aero 4B bomb container.

dropped in an emergency by actuating the manual bomb rack release. The electric cable is constructed so that it will uncouple without fouling when the container is dropped.

OPERATION.—To load the Aero 4B container, place the safety latch on SAFE. Check to see that the indexing arrow on the container body is opposite the numeral "8" on the tail fairing. Rotate the tail fairing clockwise (looking forward) until a clicking noise is heard. This aligns the first rotor position in the forward bay to receive the bomb. The bomb is pushed into the rotor with its tail to the rear. A click will be heard when the bomb is seated in the container. The latching device is tested by letting go of the bomb and giving it a slight pull. The tail fairing is then turned clockwise again until another click is heard. The rear bay rotor assembly is now in position to receive the second bomb. This procedure is continued until all eight bombs are loaded. The indicator latch should be placed in the READY position just prior to takeoff to insure proper functioning of the container during flight. If the READY-SAFE latch will not move to the READY position, it indicates that the container is completely unloaded.

Once the container is loaded and the indicator latch is in the READY condition, the bombs may be released either electrically or manually. The release shaft moves aft upon actuation. This action trips the kickout latch which holds back the spring-loaded kickout weldment. The kickout weldment then rotates under a spring load and ejects the bomb. The rotors are held stationary during this action by the kickout stop cam. When the bomb is ejected, the rotors are then freed to turn under the torque of the power spring to the next position. Then, bombs are ejected alternately from the forward and aft bays. The power used to drive the rotors in the releasing of the bombs is imparted to the power spring by winding during the loading of the container. The tail fairing is attached to the power spring mount. It winds this spring as the fairing is turned clockwise to load the bombs.

Each practice bomb is placed in a special test gage jig before loading into the container. This is to check for proper size and shape.. If casting burrs or other irregularities show up in this test, the bomb is discarded or worked over to bring it to the proper size and shape.

Aero 5 Type Bomb Container

The Aero 5 type bomb container shown in figure 9–16 is quite similar to the Aero 4B in operation. However, it is much more streamlined and designed to operate at higher aircraft speeds.

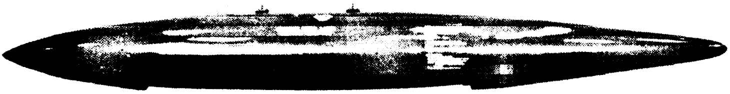


Figure 9–16.—Aero 5 type bomb container.

Intervalometer Type K–2

DESCRIPTION.—The Type K–2 intervalometer is a timing device designed to send electrical impulses to the bomb release system to release the stores at preselected time intervals. This gives the desired spacing between bombs on or across the target. The intervalometer is placed in the bomb release system between the power source and the other operating units of the system. It is actuated by the impulses received from the bombadier's control switch or the bombsight.

The K–2 intervalometer operates on the condenser charge-discharge principle. It connects and disconnects the power source to and from the electrical bomb release system. The impulses emitted are sent to the distribution unit (not a part of the K–2) of the system, and actuate the bomb releases in desired order. The number of impulses sent out as well as the frequency at which they occur may be varied as desired. The K–2 is a single wire device. All impulses emitted travel over a single wire to the various components of the release system of the aircraft to a common ground (ground return) on the chassis of the unit.

The intervalometer may be used for either a SELECTIVE or TRAIN release of stores. When set to SELECTIVE, only one impulse is generated by the intervalometer each time it receives an impulse from the bombardier or the bombsight. When set to TRAIN, the number of impulses generated by the intervalometer will be determined by the setting of the counter knob, for any unit number from 0 to 50.

The counter unit (see fig. 9–17) is composed of the counter pointer knob and pointer, counter dial, and counter switch.

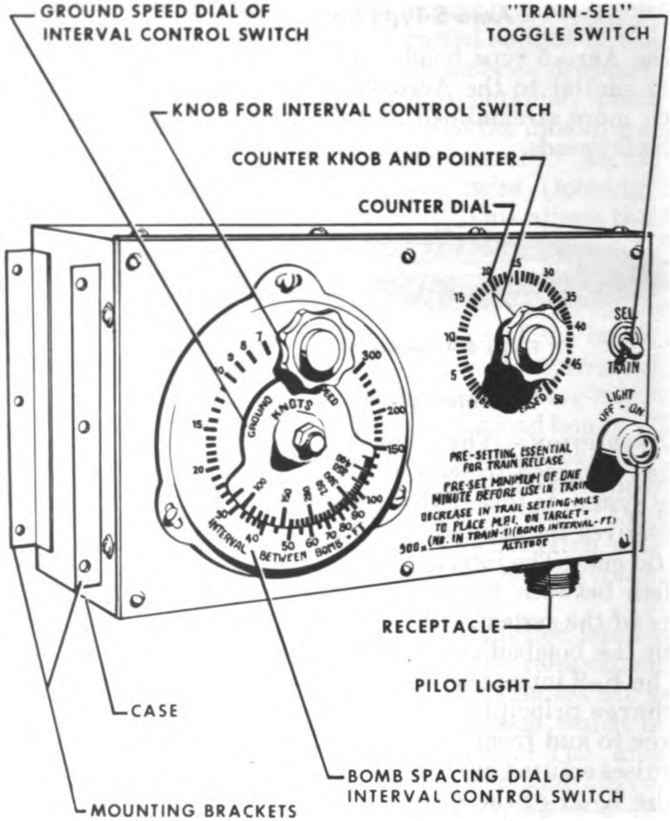

GROUND SPEED DIAL OF INTERVAL CONTROL SWITCH
"TRAIN-SEL" TOGGLE SWITCH
KNOB FOR INTERVAL CONTROL SWITCH
COUNTER KNOB AND POINTER
COUNTER DIAL
SEL
TRAIN
LIGHT
OFF - ON
KNOTS
GROUND SPEED
INTERVAL BETWEEN BOMBS - FT
PRE-SETTING ESSENTIAL FOR TRAIN RELEASE
PRE-SET MINIMUM OF ONE MINUTE BEFORE USE IN TRAIN
DECREASE IN TRAIL SETTING-MILS TO PLACE M.P.I. ON TARGET =
500 × (NO. IN TRAIN-1)(BOMB INTERVAL-FT.)
ALTITUDE
RECEPTACLE
PILOT LIGHT
CASE
BOMB SPACING DIAL OF INTERVAL CONTROL SWITCH
MOUNTING BRACKETS

Figure 9–17.—Intervalometer Type K–2, outline view.

This unit is set when TRAIN release is to be used. The counter moves one unit counterclockwise from the position set for each impulse received. When the 0 setting is reached, the counter switch opens the ground, thus stopping the action of the counter.

The interval control switch determines the number of impulses to be produced per second by the intervalometer during the TRAIN release. The device is capable of producing from 2 to 20 impulses per second. The groundspeed dial and the bomb spacing dial control the ground spacing of the bombs being released for various speeds of the aircraft.

Operation.—For SELECTIVE operation of the K–2, the toggle switch is set to the SEL, or selective position. This completes a circuit from the POSITIVE power source through the pilot light, a resistor, and the toggle switch, to the chassis (negative return). The resistor reduces the working voltage to 6–8 volts for the pilot light. Another circuit is closed from the bombardier's control switch through the connector receptacle, the SELECTIVE toggle switch, the actuating coil relay, back again through the toggle switch, and to the ground on the chassis (negative return). Closing the bombardier's control switch energizes the actuating relay. When this relay closes, the impulses flow out into the electrical bomb release system. The current will continue to flow until the bombardier's switch is opened. When this switch is opened, it charges the point condenser. This condenser prevents arcing of the actuating relay contacts as they open. Thus, with each closing of the bombardier's switch during SELECTIVE operation, one impulse is sent out into the electrical bomb release system.

Prior to TRAIN operation of the Type K–2 intervalometer, the toggle switch is set to TRAIN, the counter knob and pointer set to the desired positions, and the interval control switch set with the proper groundspeed opposite the desired ground spacing of the bombs. Setting the counter knob and pointer, lights the pilot and permits the charging of the timing condenser(s).

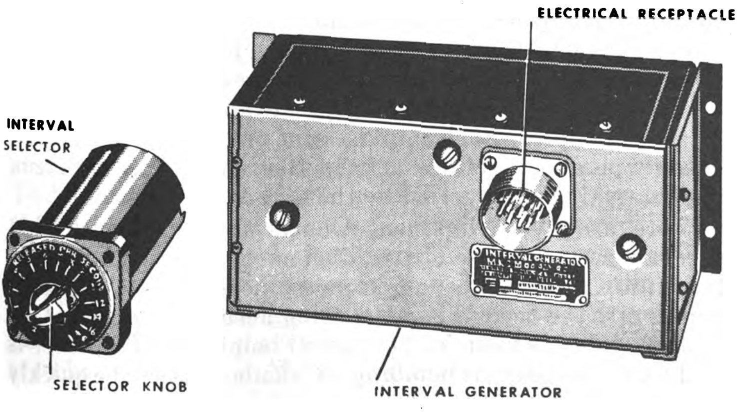


Figure 9–18.—Interval Generator Mk 1 Mod 0 and Interval Selector Mk 1 Mod 0.

The bombardier's switch, when closed, energizes the hold-in relay. This relay then becomes self-energized and remains closed for the duration of the TRAIN release. Current passing into the timing condenser discharges these condensers, and at the same time energizes the discharge relay. As the discharge relay is energized, current from its closed contacts passes through the hold-in relay. This energizes the relay and it sends out an impulse to the electric bomb release system. The timing condenser(s) is then recharged. It continues to charge and discharge, energizing the charging and discharging relays alternately. The cycle of charging and discharging will continue until the counter switch is opened upon reaching the 0 setting.

Interval Generator Mk 1 Mod 0 and Interval Selector Mk 1 Mod 0

DESCRIPTION.—The Mk 1 Mod 0 interval generator and the Mk 1 Mod 0 selector are used together to form a timing device. (See fig. 9–18.) This device is an intervalometer. The device sends out controlled electrical impulses to the bomb releases. This impulse transmission at preset intervals gives the desired bomb spacing across the target. The selector contains a selector switch for varying the frequency of the impulses sent out by the generator. The generator houses the mechanism which generates the electrical impulses. It may be mounted remotely in the aircraft as it is connected to the selector by a single wire cable.

The generator and selector are placed in the electrical bomb release system between the power source and the other units in the system. The generator operates on a condenser discharge principle. Each impulse sent out from the intervalometer operates a release unit in the bomb release system. The interval may be varied by the dial on the selector.

There are two Alignment Charts furnished with this intervalometer. These charts, or nomograms, are for use in determining the number of impulses necessary to be generated to give the desired bomb spacing across the target. One of these charts is used for horizontal bombing. The other is used for dive and glide bombing. Calculations can be quickly made on either of these charts by using a straightedge. A known or assumed value is aligned on one scale with a known or assumed value on another, and the answer is read directly from the third scale. The answer found is set on the selector to give the desired interval between bomb releases.

The interval selector is calibrated in RELEASES PER SECOND. The switch which controls the output frequency has 21 settings, permitting a selection of frequencies of from 2 to 20 releases per second inclusive.

OPERATION.—The interval selector of the intervalometer is set to the desired number of releases per second. This should be done at least one minute prior to the use of the intervalometer. This gives the timing condensers in the generator a sufficient period to become completely stabilized before use. The generator will emit impulses at the rate preselected on the selector when the bomb release switch is pressed. These impulses will continue at the preselected rate as long as the bomb release switch is depressed.

Aircraft Bomb Group Selector AN–A1 (RS–2)

DESCRIPTION.—The AN–A1 aircraft bomb group selector is a distribution device for use in an electrical bomb release system. (See fig. 9–19.) It directs electrical impulses received from the intervalometer to the various bomb groups in the aircraft, and their respective bomb rack and bomb shackle releases. The stores may be dropped in an orderly manner with this device. The main objective in using this device is to keep the weight of the aircraft balanced around its normal center of gravity. Dropping too many stores at the same time from a point remote from the normal center of gravity tends to unbalance the plane.

One bomb group selector will handle the impulses from an intervalometer to two circuits. If more circuits are to be used, other rack selectors are added to the system in series. The selector is wired so as to send the impulses alternately to the two selector circuits. Each circuit is composed of electrically connected releases (series) by means of transfer switches. This alternate transfer of impulses continues until all releases of one group have been electrically released. Later impulses are directed to the circuit having releases in a cocked condition. No loss of impulses (dead spots) occurs during this action. No impulse will be sent from a bomb group selector circuit that is not connected to its power source, or does not have releases in a cocked condition. The ground in each circuit is made through the first release that is in a cocked condition. When all releases in one circuit have been released, there will be no ground return to the group selector's transfer relay for that circuit. Thus, the relay will remain in a de-energized condition. Following impulses will be transmitted to other circuits from the group selector or other group selectors in series in which no ground return is present.

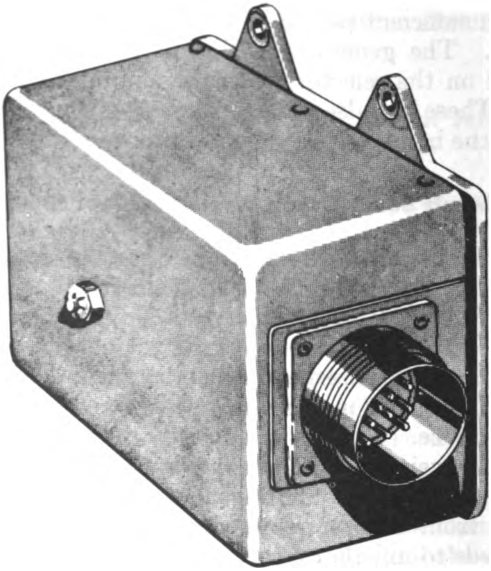


Figure 9–19.—Bomb Group Selector Type AN–A1.

A power interruption or an open ground connection of a momentary nature will alter the normal numerical sequence of release. The impulse which follows will go again to the first circuit of the group selector having its switch in a cocked condition. The first circuit of the group selector contains and is controlled by a circuit transfer relay and a hold-in relay. The second circuit contains and is controlled by a circuit relay and a hold-in relay. The two circuit relays consist of a frame assembly, coil, armature assembly, and an assembly containing seven springs and contacts. The two hold-in relays consist of the same except that there are only three springs and contacts. The group selector has a maximum speed of operation of 22 impulses per second. There is a minimum period between impulses of 0.02 second.

OPERATION.—The operation of the AN–A1 bomb group selector is very complicated. Details of its operation will not be given in this chapter, but may be found in the pertinent NAVAER publications.

SAFETY PRECAUTIONS.—No attempt should be made to clean, repair, or adjust the AN–A1 bomb group selector. This selector is classed as a "technical item." It can be repaired and adjusted properly only at major overhaul points.

The relay windings of the selector are designed to operate with solenoids similar to those in Mk 1, A–2, and AN–A–2 releases. Proper operation will not be obtained with releases having high inductance solenoids.

The master switch should be snapped OFF and ON again after bombs have been loaded in the aircraft and the bomb group selector switches positioned. This should be done prior to releasing any bombs. This action will correct any errors occurring in bomb loading procedure, or in the operation of the bomb group selector switches.

Station Selector Mk 2

DESCRIPTION.—The Mk 2 station selector is used to fire rockets electrically and to release bomb stores, singly or in pairs, from aircraft. Electrical impulses passing through the selector are routed to the preselected station or pair of stations. A solenoid-actuated device automatically advances the contacts to the next open position after the impulse ceases. This action makes ready the next set of contacts for the following impulse.

The Mk 2 selector is designed to fit the standard aircraft instrument panel. There is a choice of several different dials for use with this selector. These dials are selected in accordance with the number of stations involved. The entire instrument is housed in a cylindrical can which acts as a seal from dirt, moisture, and dust.

OPERATION.—Circuit connections in all Mods of the Mk 2 selector are made by means of an external firing key or intervalometer. (See fig. 9–20.) These connections are made through the solenoid coil (1) to the contact ring (4). From here the connection is completed to any one or pair of contact terminals. Electrical impulses received from the firing key or intervalometer energize the solenoid (1). This, in turn, causes the armature (2) to be cocked and ready for the advancement of the contact arm assemblies (3). These arm assemblies are mounted so that electrical contact is established between the contact ring (5) and the terminals (6).

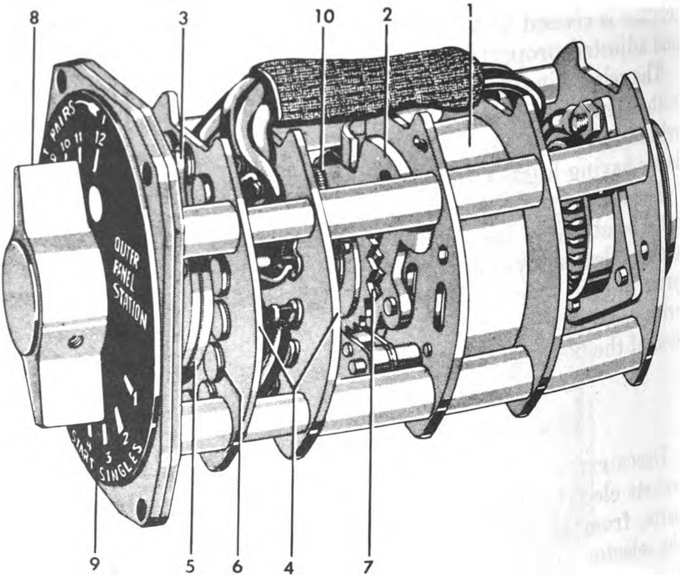


Figure 9–20.—Station Selector Mk 2 Mod 0.

As soon as the impulse ceases, the instrument advances itself to the next open position automatically. This action is accomplished by armature and pawl assembly (2) acting on the ratchet and detent assembly (7). The movement to the next position is the direct result of the armature spring (10) tension. This spring pulls the armature and its pawl to the normal, or inoperative, position. Operation of the device is provided by setting the index knob (8) to the desired position on the dial (9) and introducing an electrical impulse from either a firing key or intervalometer.

Model 6127 ASW Stores Launcher

DESCRIPTION.—The Model 6127 antisubmarine warfare stores launcher is an electrically controlled, pneumatically (air pressure) operated ejector. (See fig. 9–21 (A).) It is used primarily to eject ASW sonobuoys and other stores of

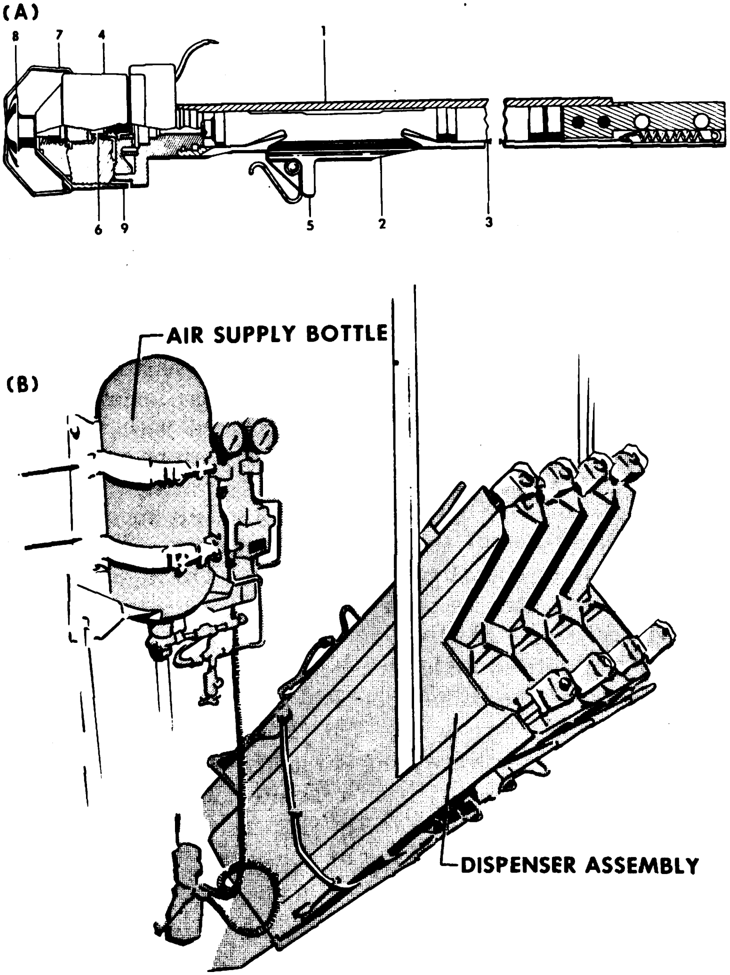


Figure 9–21.—(A) Functional view of ASW store launcher; (B) Model 858 Eight Tube Sonobuoy Dispenser.

the same general shape from an aircraft in flight. This launcher will eject these stores at right angles to the aircraft into a 250 m. p. h. airstream under a working pressure of 750 p. s. i. A reduction in airspeed permits the launcher to operate successfully at 400 p. s. i.

The major components of the Model 6127 launcher are the cylinder (1), the piston assembly (2), the ribbon assembly (3), the air valve assembly (4), and the manual override (8). The body of the launcher consists of a slender steel tube, or air cylinder. The piston finger (5) extends from the piston body and engages the store. The slot is sealed at all times on both sides of the piston by a thin steel ribbon (3). High pressure air forces the ribbon into a close seal with the track on the power side of the piston. This forms a practically airtight seal. The solenoid operated air valve (4) is mounted on the upper end of the cylinder. Both the piston and the ribbon assembly are housed here also.

When the solenoid opens the air valve, pressure is exerted against the piston. The piston finger then ejects the store as the piston reaches the end of its travel in the air cylinder. The piston must be returned to the firing position after each launching. A manual override is provided with which to trip the solenoid operated air valve in the event of a power failure. To operate the manual override, release the spring clip (7), and pull the override knob (8). This knob projects from the head (9) of the air valve assembly. This action causes the pilot valve (6) to be unseated. The high pressure air is then admitted to the cylinder in the same manner as when operated electrically.

The Model 6127 store launcher may also be used as a component part of the Model 858 Eight Tube Sonobuoy Dispenser Assembly. (See fig. 9–20 (B).) In this assembly, eight of the launchers are ganged together into one assembly and controlled electrically from a remote point. In the event of electrical power failure to the dispenser, the stores may be manually ejected by means of a manual release control. This control actuates the pneumatic ejector without the necessity of depressing the pushbutton switches located on either side of the pilot's control panel. The Model 858 dispenser assembly is used to launch sonobuoys, bathythermographs, and flares from patrol type aircraft. The dispenser assembly launches its stores from within the aircraft, through a door in the skin, by the same method of operation as described in the ASW store launcher section. It will accommodate eight stores at one loading which may be released at the option of the operator either in individual launchings, in a timed sequential train release, or in a high-speed release series.

Safety Precautions

The inherent dangers associated with the handling of aircraft MUNITIONS demand that every conceivable precaution be taken at all times. There is absolutely no place for slipshod workmanship or second guesses. Bitter experience has taught that inaccuracies and carelessness are disastrous. So it is, also, in the handling of the devices which carry and release these dangerous stores.

Only the major precautions connected with the suspension, arming, and releasing devices detailed in this chapter have been mentioned. It is easily seen that safety in employment of aircraft munition stores is dependent to a large degree upon the devices which carry and release them. No bomb, torpedo, mine, or rocket is any safer than the device with which it is used or the personnel handling it. It is, therefore, essential that the safety precautions associated with the installation, maintenance, and testing of these devices are thoroughly understood. Instructions are written for the safe employment of each piece of armament gear.

In order for the Aviation Ordnanceman to get a comprehensive picture of the safety precautions necessary to safety within his activity, he should study the precautions covering all phases of handling, stowage, and employment of aviation ordnance, armament, and munitions. This may seemingly be a rather large task, but when it is realized that most safety precautions have been written as a direct result of unfortunate events of the past, it is apparent that one cannot afford to be ignorant of even a single precaution. Some of the publications helpful in learning these precautions are:

Bureau of Ordnance Manual
Bureau of Aeronautics Manual, NavAer 00-25-500
Safety Precautions, NavOrd 5100.1
Ordnance Safety Precautions, OP 1014
Ammunition Handling, NavPers 16194

BuDocks Instruction 11142.2.
BuOrd Instructions
BuOrd Notices

A careful reading of the pertinent sections of the above publications plus the precautions published locally by your command and your activity will furnish the necessary information.

QUIZ

1. The Aero 14B bomb rack and rocket launcher has
   a. 30-inch suspension
   b. single hook suspension
   c. manual release
   d. two hanger bolts
2. The Aero 17A bomb shackle has a capacity of
   a. 4,000 pounds
   b. 2,000 pounds
   c. 2,500 pounds
   d. 2,240 pounds
3. The Intervalometer Type K–2 is a timing device capable of sending out a maximum number of impulses in one setting of
   a. 32
   b. 22
   c. 50
   d. 20
4. The arming of the bomb suspended on the Aero 14B bomb rack and rocket launcher is
   a. fully selective
   b. manual
   c. semiselective
   d. accomplished by one arming solenoid
5. When using the manual control for arming the Mk 51 Mod 11 bomb rack
   a. the nose fuze will arm first
   b. The tail fuze will arm first
   c. both nose and tail will arm simultaneously
   d. the bomb will drop in the SAFE condition
6. The features which were deleted from the Mk 51 Mod 12 bomb rack are the
   a. indicator light and the manual release
   b. electrical arming and the manual release
   c. transfer switch and the manual arming
   d. electrical release and the electrical arming

7. The Aero 17A bomb shackle may be released by the
    a. Bomb Shackle Release Mk 1 Mod 0
    b. Bomb Shackle Release Mk 1
    c. Bomb Shackle Release Mk 1 Mod 4
    d. Bomb Shackle Release Mk 1 Mod 2

8. The Mk 2 station selector is designed for firing rockets or dropping bombs
    a. manually or electrically
    b. in pairs only
    c. singly or in pairs
    d. singly only

9. After every 40 shots with the Douglas bomb ejector, the
    a. O-rings should be replaced
    b. ejector should be cleaned and piston rings replaced
    c. hooks synchronized
    d. ejector completely disassembled and cleaned

10. The Aero 14B combination bomb rack and rocket launcher will suspend and transport a
    a. 1,000-pound, 2-lug bomb
    b. 500-pound, 2-lug bomb
    c. 1,000-pound, 1-lug bomb
    d. 500-pound, 3-lug bomb

11. The purpose of the quick disconnect on the Mk 51 bomb rack is to replace the release assembly without disassembling the
    a. arming unit
    b. connecting link
    c. electrical receptacle
    d. release trigger

12. The Douglas bomb ejector is
    a. a wing mounted combination bomb rack and rocket launcher
    b. a bomb rack launcher only
    c. an ejector bomb rack
    d. used for launching subcaliber rockets

13. The maximum capacity of the Aero 14B bomb rack is
    a. 260 pounds
    b. 1,000 pounds
    c. 1,600 pounds
    d. 500 pounds

14. When the indicator on the Aero 4B bomb container fails to go into the READY position it would indicate which of the following conditions?
    a. Rack fully loaded
    b. Rack partially loaded
    c. Rack completely unloaded
    d. Electrical receptacle disconnected

15. In TRAIN position the K2 intervalometer is actuated by an impulse received from the
    a. rack selector
    b. station distributor
    c. stepping relay
    d. bombardier's switch

16. Actual ejection of bombs from the Douglas bomb ejector is accomplished by
    a. hydraulic pressure
    b. gas pressure
    c. the manual release
    d. the weight of the bomb

17. The correct cleaning solution for the Douglas bomb ejector is a mixture of
    a. glycerin and water
    b. glycerin and litharge
    c. litharge and acetone
    d. water and acetone

18. The length of the electrical cable (pigtail) for Aero 4A bomb shackle release is
    a. 6 inches
    b. 12 inches
    c. 16 inches
    d. 33 inches

19. When the Mk 1 (and Mods) bomb shackle release is not being used it should be kept in which of the following conditions?
    a. Cocked position
    b. Preserved
    c. Released position
    d. Forward position

20. The Aero 4B bomb container of a grounded aircraft may be checked by which of the following methods?
    a. Electrically or manually
    b. Manually only
    c. Electrically only
    d. Salvo only

21. The maximum airspeed for operating the Model 6127 ASW stores launcher at 750 p. s. i. is
    a. 160 m. p. h.
    b. 200 m. p. h.
    c. 250 m. p. h.
    d. 300 m. p. h.

22. The modified hoisting bracket was first introduced on the
    a. Mk 51 Mod 10 bomb rack
    b. Mk 51 Mod 11 bomb rack
    c. Mk 51 Mod 12 bomb rack
    d. Mk 51 Mod 7 bomb rack

23. The Aero 14B combination bomb rack and rocket launcher with the Aero 1A adapter installed will suspend and launch the
    a. ATAR rocket
    b. HVAR rocket
    c. ASW rocket
    d. subcaliber rocket

CHAPTER 10

GUN CAMERAS

Both pilot and aircrewman have learned a great deal about the techniques of aerial gunnery and the airmanship involved from films produced by the gun cameras attached to the aircraft. Photography is an exceptional training medium. Movies taken during gunnery exercises and in actual combat by the automatic gun camera, and later viewed by projection, show graphically the mistakes made during the practice or mission in addition to those firing runs which were perfectly executed. The value of the gun camera in practice and combat has become so apparent over the past few years that it is routine to equip training and combat aircraft with these cameras. Assessment of damage to enemy aircraft and installations is quickly and accurately determined by intelligence personnel from moving picture sequences made by the gun camera. Provisions for rapid development of these movie sequences exposed in the gun cameras have been made both ashore and afloat. It is not uncommon for the pilots and aircrewmen returning from a mission to view the films they exposed only a short while previously.

The Aviation Ordnanceman will not be called on to know the operation and maintenance of the camera guns in detail. When found to be faulty, these cameras are sent to overhaul where qualified personnel make the necessary repairs. However, since the gun camera is placed in the same electrical circuit with other components of aircraft fire control, it is well for the ordnanceman to have a basic knowledge of the function and operation of these cameras. The information given in this chapter is therefore fundamental in scope and nature.

AN Type Gun Cameras

The aircraft gun cameras to be studied in this chapter are the AN–N–4, AN–N–4A, AN–N–6A and the Mk 8 Mod 0.

DESCRIPTION.—A great many of the mechanical features of any one of these cameras are common to all the others. This is the reason that they are all discussed together. Therefore, EXCEPT WHERE OTHERWISE NOTED, the description and information given in this chapter apply to all of the above gun cameras. Table 10–1 gives the operating voltage, manufacturer, and lens of each model.

Table 10–1.—Details of AN type gun camera.

Type	Volts	Manufacturer	Lens focal length
AN–N–4	24	Fairchild Camera and Instrument Corp.	35-mm
AN–N–4A	24	Bell and Howell Company	35-mm
AN–N–6A	24	Bell and Howell Company	35-mm
Mk 8 Mod 0	24	Bell and Howell Company	35-mm

All AN type gun cameras are ruggedly constructed, electrically operated motion picture cameras. They all use 16-mm film loaded in magazines. They are designed for recording results obtained in aerial gunnery training and in actual combat. Both the AN–N–6A and the Mk 8 Mod 0 gun cameras have built-in overrun controls. On the other cameras, the overrun control is a separate unit and its use is optional. The Mk 8 Mod 0 gun camera is a converted AN–N–4A, and contains the overrun control unit as a built-in feature. The overrun control allows the camera to continue to operate for a preset time after the trigger control switch has been released. A small pin-like indicator is released during the time the camera is operating in the overrun condition and projects into the picture aperture. Its image is recorded on the film, indicating the part of the film exposed while the camera was operating by the overrun control mechanism. A removable photographic filter, Wratten No. 12 (minus blue), is attached to the lens assembly of all AN type gun cameras. The AN–1 boresight is used to align the camera with the guns and gunsight.

Camera housing.—The housing of the gun camera body assembly is corrosion-resistant. The materials used in its manufacture are able to withstand ordinary vibration and extremes in temperature. The housing encloses the components of the camera and provides space for the film magazine.

Footage indicator.—A manually set footage indicator dial is mounted on the side of the camera. It indicates the number of feet of film still unexposed. (See fig. 10–1.)

Speed change dial.—A manually operated speed change dial controls the number of frames per second that are being exposed. (See fig. 10–1.) This dial changes the gear ratio of the gear train, but does not change the speed of the electric motor. The speed of the constant speed motor remains unchanged as long as the voltage remains constant.

Film magazine access door.—There is a hinged door (cover) at the rear of the gun camera which permits inser-

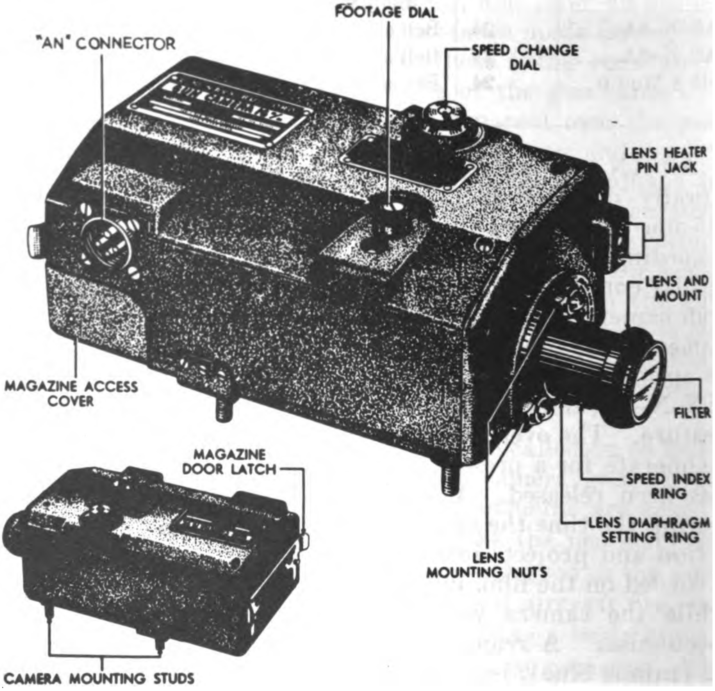


Figure 10–1.—AN type gun camera.

tion and removal of the film magazine. (See fig. 10–1.) It has a spring lock which automatically engages when the door is shut. Shutting this access door on the Bell and Howell cameras presses the finger on the side of the door against the magazine clutch lever. This clutch lever then pushes the magazine drive spline to engage the drive socket of the magazine. On the Fairchild cameras the magazine latch, when pulled across the rear of the magazine, locks the magazine in place. This same movement of the latch also raises the magazine drive spline to engage it with the drive sprocket of the film magazine.

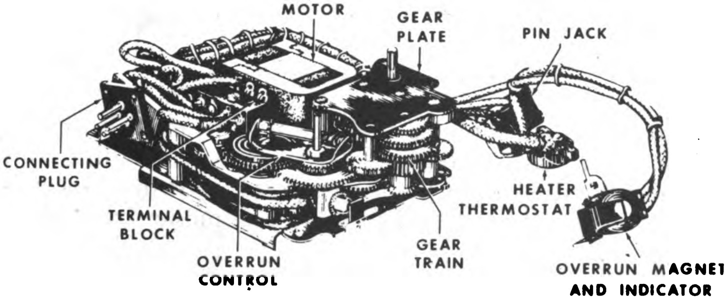


Figure 10–2.—AN–N–6A body mechanism.

Electric motor.—A 24-volt constant speed motor drives the AN–N–4, AN–N–4A, AN–N–6A, and the Mk 8 Mod 0 gun cameras. Earlier models of the Bell and Howell cameras had permanent magnets to provide field excitation. However, the later Bell and Howell models and all the Fairchild cameras use a field coil to effect this excitation. The AN–N–6A and the Mk 8 Mod 0 cameras both use General Electric motors because they are small enough to permit incorporation of a built-in overrun control, both housed within the camera case. (See fig. 10–2.) A built-in governor keeps the motor at a constant speed regardless of whether or not the camera is being operated at 16, 32, or 64 frames per second.

Takeup gear assembly.—This assembly contains a small spring-operated clutch which slips if the film in the AN–A–6 magazine jams or does not operate freely. (See fig. 10–3.)

Motor stall thermostat.—All AN type gun cameras are

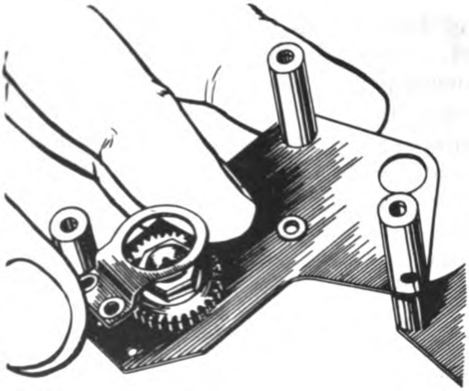


Figure 10–3.—Takeup gear assembly.

equipped with an integral stall thermostat, or heat switch. If the motor stalls or fails to start due to overloading, this thermostat will shut off the power supply within 35 seconds after stalling occurs. This prevents the motor from burning out.

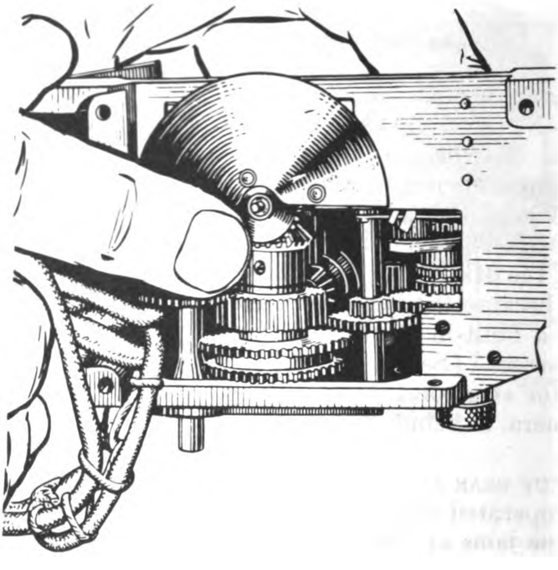


Figure 10–4.—Shutter with drive gear.

Shutter.—The AN–N–4A, AN–N–6A, and the Mk 8 Mod 0 gun camera shutters are sector plates having a cutout segment of 135 degrees. As the sector plate rotates, this cutout segment admits light intermittently to the film magazine. The AN–N–4 camera has a cone-shaped shutter with a cutout segment of 150 degrees. Both types of shutters give exposures of $\frac{1}{45}$, $\frac{1}{90}$, and $\frac{1}{180}$ second while the cameras are operating at 16, 32, and 64 frames per second respectively (See fig. 10–4.)

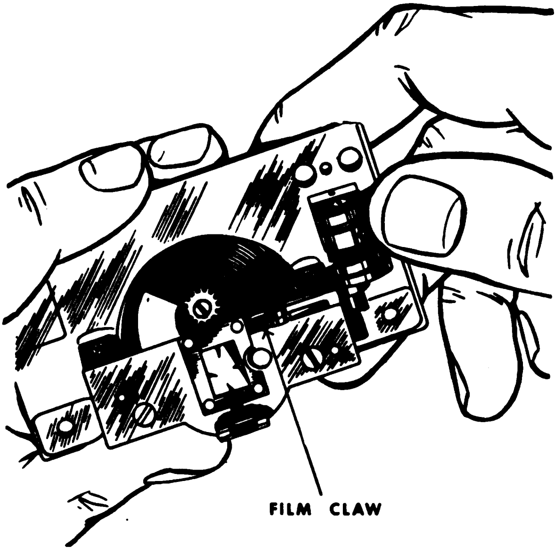


Figure 10–5.—View of Fairchild camera film claw and claw eccentric.

Film drive mechanism.—All of the Fairchild cameras have a **film claw** to move the film intermittently in front of the film aperture. The Bell and Howell cameras use a shuttle for this purpose. (See fig. 10–5.) The magazine drive spline rotates the magazine sprocket which turns and winds the exposed film onto the takeup spool in the film magazine.

Fiducial marks.—All the gun cameras except the AN–N–6A have four fiducial markers located at the corners of the four sides of the film aperture. (See fig. 10–6.) These markers reproduce their images on the film during exposure. The marks made are used for references in scoring. The

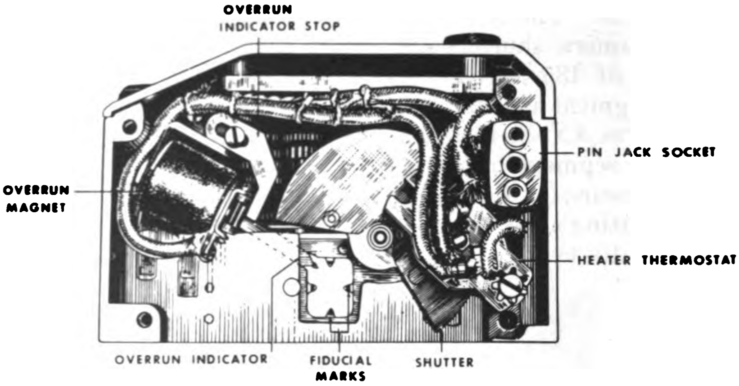


Figure 10–6.—Gun camera with front plate removed.

center point of lines drawn between opposite fiducial marks on the film show the exact center of the frame. This point, projected into space, is considered to be the center of the line of sight. Assessing is done to this projection.

Heating element.—Thermostatically controlled heating elements are standard equipment on all AN cameras. They prevent the mechanisms of the cameras from becoming sluggish in low temperature operation. In some cases, they prevent stoppage caused by the congealing of the lubricants. The thermostats are adjusted so that they start operating when the temperature inside the camera drops to 45 degrees Fahrenheit. It shuts off when this temperature reaches 100 degrees Fahrenheit. (See fig. 10–2.)

Overrun control.—The overrun control allows the camera to continue to operate after the firing switch is released. This permits the camera to record the results of the fire on the target. As previously mentioned, the overrun controls on the AN–N–6A and the Mk 8 Mod 0 are built into the gun camera. (See fig. 10–2.) The adjustment for the overrun period may be varied from one to five seconds in increments of one second.

Overrun control indicator.—The overrun control indicator is a pointer (much like the fiducial marks) which is projected into the corner of the film aperture by the action of an electromagnet. (See fig. 10–2.) During the overrun period, this indicator is released into the film aperture by the electromagnet. Its image is recorded on the film for the duration of the overrun period. When the firing is again commenced, the electromagnet withdraws the indicator from the film aperture.

COMPLETE PLAIN LENS ASSEMBLY.—The gun camera lens components are highly corrected and accurately ground elements. These elements are mounted in a heavy protective sheath and flange unit. (See fig. 10–7.) Three holes in the lens mount flange provide means of securing the lens assembly to the front plate of the camera. In setting the lens diaphragm, the shutter speed indication on the upper part of the index ring, (1) of figure 10–7, must be set against the index mark on the lens barrel. It is very important that the index ring on the lens and the shutter speed change dial (fig. 10–1) are ALWAYS set at the same shutter speeds. The diaphragm ring, (3) of figure 10–7, is then adjusted so that its index mark is set against one of the marks on the diaphragm. These marks will be either "B," "H," and "D," or f-stops from f3.5 to f16, depending on the camera in use.

There are three filters for use with the AN type gun cameras. The filter (5) screws on the end of the lens assembly, as shown in figure 10–7. A yellow glass (minus blue) filter, an optical clear filter, and a Kodachrome haze filter are used interchangeably under differing light conditions and with varying film materials. Table 10–2 shows the type and use of each filter.

Table 10–2.—Types and uses of gun camera filters.

Type	Use
Minus blue	All normal light conditions.
Optical clear	Under adverse light conditions.
Kodachrome haze	All Kodachrome film.

AN–1 BORESIGHT.—The AN–1 boresight is used to align the optical axis of the AN type gun cameras with boresight axes of the gun and gunsights. (See fig. 10–8.) This boresight consists of a housing (3) which is shaped to conform

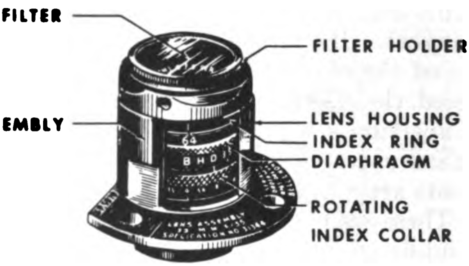


Figure 10–7.—Gun camera lens assembly set at speed 64 and DULL.

to the dimensions of the AN–A–6 film magazine. Its components are a field lens, a reticle glass (2), and an eyepiece (1). The cross hairs on the reticle glass indicate the optical center of the camera aperture. The 8-inch focal length eyepiece which fits into the end of the housing has a 90-degree prism, and can be rotated through 360 degrees when the boresight is inserted into the film magazine compartment. All late procurement AN–1 boresights have an extra attachment which enables the operator to look straight through the boresight without using the 90-degree prism.

The AN–A–6 film magazine.—The AN–A–6 film magazine is used with the AN type gun cameras described in this chapter. (See fig. 10–9.) It is a self-contained motion picture camera magazine. It holds a maximum of 50 feet of 16-mm roll film. A footage indicator dial on the cover plate shows the amount of unexposed film remaining in the magazine.

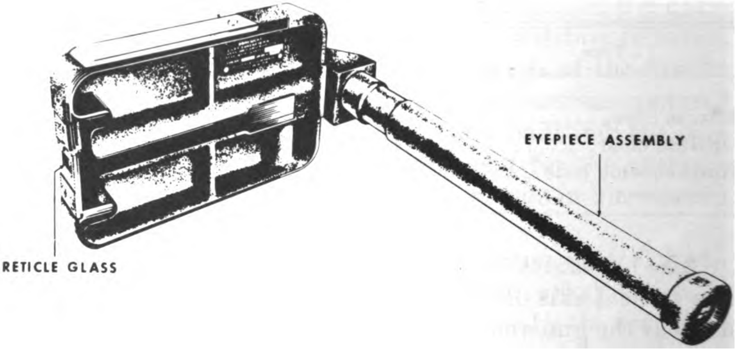


Figure 10–8.—Type AN–1 boresight.

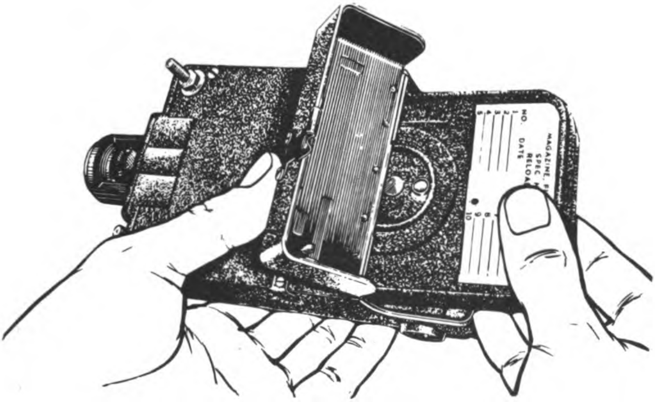


Figure 10–9.—The AN–A–6 gun camera magazine.

INSTALLATION.—Provisions for mounting the camera are made on all fighter type aircraft and in the turrets of some medium and heavy bomber types. In the fighter types, the gun camera is mounted within the wing in most instances. Certain installations are made in which the camera is placed adjacent to the gunsight. In these instances an erector (fig. 10–17) is used to mount the camera at a 90-degree angle to the longitudinal axis of the aircraft. The gun cameras are so positioned, boresighted, and adjusted that they will photograph targets at which the aircraft's guns are aimed.

There are many types of gun camera mounts used in the Navy. Each type of aircraft may have a different installation requiring the use of a mount which is different in some respects to the others. There is no need in this chapter to attempt to discuss them all. The basic function of the mount is to secure the gun camera to the aircraft in such a manner that the camera will be able to photograph the results of the gunfire. Provisions must be made to adjust these mounts so that the optical axes of the gun cameras mounted thereon are aligned with the guns and gunsights. These mounts must also be compact, easily adjusted, and placed within the structure of the aircraft at locations easily reached for boresighting, loading, and unloading of the camera. Their locations should also be free of vibrations. One type of gun camera mount provided has a spring-loaded frame outside another frame in which the camera is mounted on rubber shock mounts to eliminate vibrations. Others fasten rigidly to the aircraft's structure and incorporate various attaching devices for the gun cameras.

The gun camera with complete lens assembly installed is secured to the gun camera mount by four mounting studs and nuts. This complete assembly is installed in the wing or attached to the turret of the aircraft. In other installations the mount is secured to the aircraft and the camera then bolted to the mount.

BORESIGHTING.—Before attempting to boresight the AN camera, the shutter has to be opened. To do this, it may be necessary to connect the gun camera power cable and depress the pilot's stick control switch for a few short "bursts" until the shutter stops in the OPEN position. Check the position of the shutter by looking into the magazine chamber after each "burst."

The housing of the AN-1 boresight is inserted into the gun camera magazine chamber. The side of the boresight having the retaining spring is placed towards the mount side of the camera. The speed index diaphragm is set at 64 frames per second, and the other diaphragm is set to the largest f-stop ("D," or f3.5, depending on the model of the camera). Sight through the eyepiece of the boresight. The crossed reticle lines indicate the optical center or aiming point of the gun camera.

NOTE: If the crosslines of the boresight and the camera fiducial marks do not coincide, the camera should be removed and sent to overhaul.

The gun camera is shifted within the gun camera mount and adjusted until the target is centered on the crosslines (cross hairs) of the boresight. The camera is then locked in this position by the gun camera mount locking device.

Caution: Make sure the switch controlling the operation of the camera is in the OFF position until the camera is to be operated. If the temperature drops while the camera ON-OFF switch is in the ON position, the thermostatically controlled heater may automatically commence operation. This will drain the battery.

OPERATION.—Aircraft gun cameras are designed for recording the results obtained in aerial gunnery training and in actual combat. When correctly installed and boresighted, these cameras record all phases of action during the firing of the guns.

The AN type gun cameras contain within the camera bodies a speed change unit which offers a selection of three shutter speeds. Control of these speeds is effected by a speed change knob and dial on top of the camera case.

Caution: When operating the speed change knob, be sure that all motion of the camera mechanism has stopped before the change is made. Failure to observe this precaution will result in stripped gears in the speed change unit.

Before operating the gun camera, remove the cover (on the AN–N–6A and the Mk 8 Mod 0 cameras) and set the overrun control for the desired time period. Set the speed of the shutter and adjust the lens diaphragm for the anticipated light conditions. The shutter speeds indexed on the lens are marked in three speeds—16, 32, and 64 frames per second. The lens diaphragm also has three settings—BRIGHT, HAZY, and DULL. The late AN–N–6A cameras have diaphragm settings indicated in f-stops. These stops are f3.5, f4.5, f5.6, f8, f11, and f16. With this number of settings it is possible to set the correct exposure for a wider variety of light conditions than with the other models of AN type gun cameras having only three diaphragm settings.

Caution: There is a yellow glass (minus blue) filter screwed on the front of the lens assembly of all gun cameras described in this chapter. This filter should not be removed from the camera except to clean it, or exchange it for either the optical clear or the Kodachrome haze filters. The lens settings on the camera are all precalibrated to compensate for the filter factor of the yellow glass (minus blue) filter. This means that the filter factor of the yellow filter does not have to be added to the computations of exposure under the prevailing light conditions. It has already been taken care of, or added to the carefully computed settings of the lens assembly. The optical clear and the Kodachrome haze filters may be used with the compensated precalibrated settings without fear of overexposures resulting.

LOADING THE AN–N–4 GUN CAMERA.—Open the film magazine access cover while pressing the door latch knobs forward towards the camera body. Push the magazine access cover towards the camera mount. Move the magazine latch

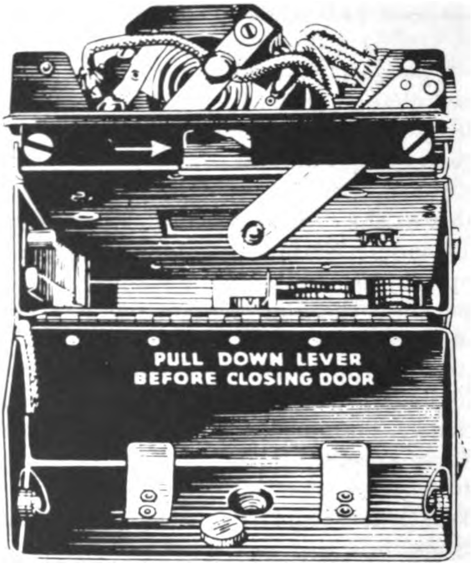


Figure 10–10.—AN–N–4 magazine access cover.

(fig. 10–10) out of the way to allow for loading. This retracts the magazine drive spline from the magazine chamber. The magazine is inserted with its aperture forward and its footage indicator towards the mount side of the camera. Move the magazine latch over the end of the magazine as far as it will go. This engages the spring-loaded drive spline

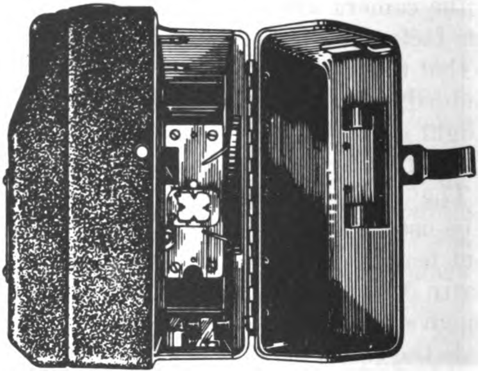


Figure 10–11.—AN–N–4A magazine access cover.

with the magazine. Note the footage of unexposed film showing on the footage indicator of the AN–A–6 film magazine, and close the access cover. Set the film footage indicator of the camera according to the footage reading taken from the magazine previously.

Loading the AN–N–4A, AN–N–6A, and Mk 8 Mod 0 cameras.—These cameras are loaded in the same manner as the AN–N–4 except that the magazine access cover has a spring latch which is lifted to open the cover. Also, on these cameras there is no magazine latch which has to be moved out of the way for loading. The pin on the edge of the magazine must engage the magazine pressure spring before it will operate. Thus, it is important to push the maga-

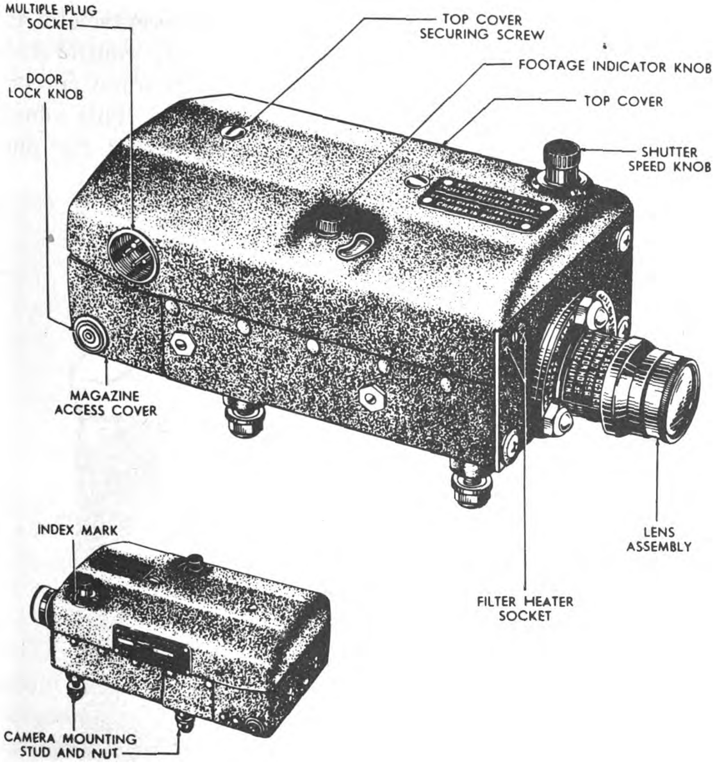


Figure 10–12.—AN–N–4 gun camera.

zine forward until there is an audible click before closing the access cover. (See fig. 10–11.)

Setting the film footage indicator.—The footage indicator dial on the AN–N–4 gun camera is set by pushing in and turning the footage indicator knob to the desired setting. (See fig. 10–12.) On all the other types it is set by simply turning the knob. (See fig. 10–1.) If a full magazine is being inserted, turn the footage indicator knob to the "0" setting. This indicates that none of the film has been exposed. If a partially used magazine is being loaded into the camera, set the footage indicator on the camera to correspond with that shown on the indicator dial of the film magazine.

Making electrical connections.—Insert the cable plug from the power supply into the four-pin receptacle of the camera. This cable is connected to the pilot's control stick. In the late AN gun cameras, the number three pin (prong) of the receptacle is larger than the others. This affords positive identification for correct alignment of the plug

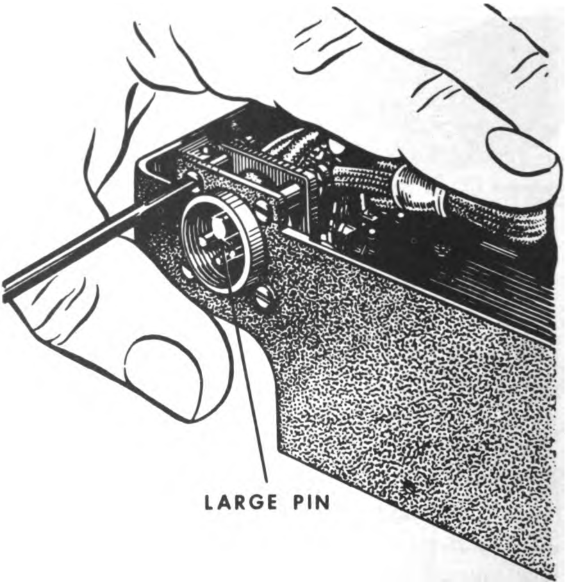


Figure 10–13.—AN type gun camera receptacle.

when it is inserted into the receptacle. (See fig. 10–13.) In the earlier models all pins were the same size. This required that the plug be inserted into the receptacle only after careful study of both the plug and receptacle to determine exactly how the plug was to be correctly inserted.

Caution: Failure to make proper connections between the power cable and the gun camera receptacle WILL CAUSE THE GUNS TO FIRE AUTOMATICALLY.

SETTING OVERRUN CONTROL ON AN–N–6A AND MK 8 MOD 0 GUN CAMERAS.—Remove the four fillister-head screws from the cover and take it off. Set the overrun stop lever, (7) of figure 10–2, for the desired overrun control period. Replace the cover. If it is desired to operate these cameras without the overrun control, this control should be bypassed. To bypass the overrun control, pull out the PINK (sometimes red) wire from the number four socket on the terminal block, and plug it into the number two socket. (See fig. 10–14.)

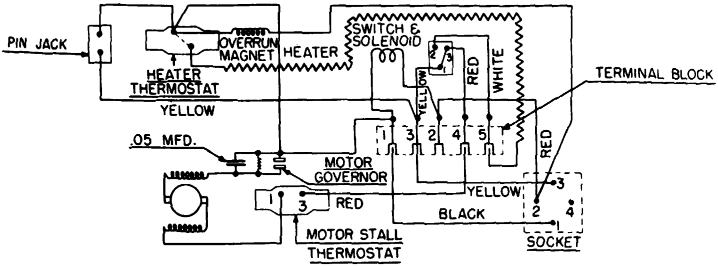


Figure 10–14.—AN–N–6A wiring diagram.

Table 10–3 shows the number of frames and feet of film exposed for each second of overrun time for the different shutter speed settings.

All gun cameras and their accessories are precision instruments. No attempt to dismantle or to repair these cameras should be made by personnel not specifically trained in their maintenance. Gun cameras found to have internal electrical troubles, to be rusted and corroded, or otherwise faulty or inoperative, should be removed from the aircraft and sent to the overhaul activity.

Table 10–3.—Number of frames and feet of film exposed for each second of overrun time for different shutter speeds.

Time in seconds	16 speed		32 speed		64 speed	
	Frames	Feet	Frames	Feet	Frames	Feet
1	16	0. 4	32	0. 8	64	1. 6
2	32	0. 8	64	1. 6	128	3. 2
3	48	1. 2	96	2. 4	192	4. 8
4	64	1. 6	128	3. 2	256	6. 4
5	80	2. 0	160	4. 0	320	8. 0

Gunsight Camera Type CG–4

Description.—The type of CG–4 gunsight camera is an electrically operated still picture camera. It uses 16-mm film loaded in magazines. It is especially designed for recording photographically the aiming reticle and the target of the Mk 18 and Mk 23 computing gunsights. However, the CG–4 may also be used on the Aircraft Fire Control Systems, Mk 5, Mk 6 Mod 1, and Mk 15. Use is made of this camera both in aerial gunnery training and in actual combat.

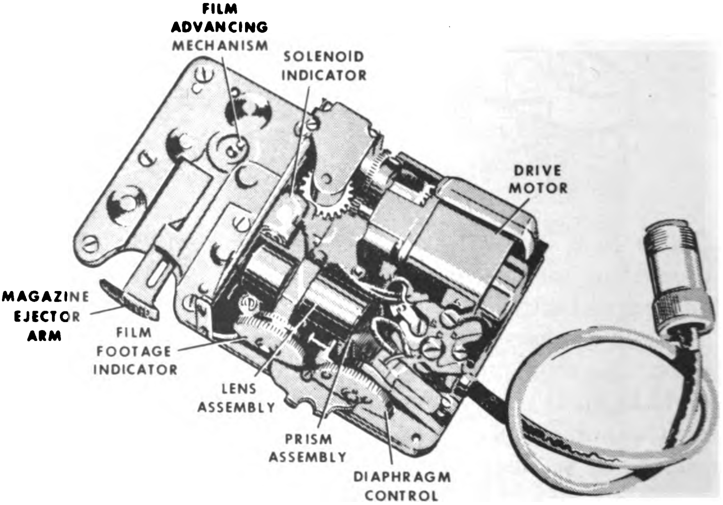


Figure 10–15.—Gunsight camera, interior view.

The gunsight camera main body plate assembly (fig. 10–15) contains a film advancing mechanism (1), film footage indicator (15), lens assembly (14), prism assembly (12), drive motor (9), and other necessary component parts.

The film footage indicator (15) is actuated by the film advancing mechanism, and indicates the AMOUNT OF FILM EXPOSED in increments of one foot. This indicator may be reset at any time without damage to the camera.

The shutter of the gunsight camera is of the focal plane type. It has exposure settings of 1/100 and 1/200 second, and is capable of repeated operation at a rate of three frames per second.

The film advance mechanism engages the film in the magazine and advances it intermittently past the film aperture. A claw does the actual advancing of the film as the film is wound on the takeup spool. The lens assembly consists of an anastigmat f3.5 lens (14) of 35-mm focal length and an iris diaphragm and control (11). The diaphragm control is located on the front of the camera, and is controlled by detent settings marked DULL, HAZY, and BRIGHT. These settings correspond respectively to stops f3.5, f5.6, and f8.

The prism (12) is a right angle, totally reflecting element. It is mounted in such a manner as to transpose the vertical axis of the light beam reflected from the sight mirror to the horizontal plane of the film magazine.

The electric motor is a specially designed 27.5-volt d-c miniature unit.

A solenoid indicator (2) is made to extend into the light path at the focal plane of the shutter aperture. It projects its image on the film as each picture is taken during ranging. When it is not desired to have this "witness mark" on the picture, the indicator is withdrawn from the light path by energizing the solenoid remotely by a switch.

The magazine ejector (18) locks the magazine in the magazine recess (the recess is formed when the cover is secured to the main body assembly plate of the camera) in such a position that the film opening of the magazine registers perfectly with the focal plane of the camera. A push on the ejector arm will eject the film magazine.

The MG–1 magazine used with the CG–4 gunsight camera incorporates the film advancing mechanism. It is loaded with 20 feet of 16-mm motion picture film. This is enough film for about 800 exposures.

The M1G–2 gunsight camera mount is used for mounting the CG–4 camera on the Mk 18 and Mk 23 gunsights. This mount positions the camera over the gunsight at the exact focal point desired. (See fig. 10–16.)

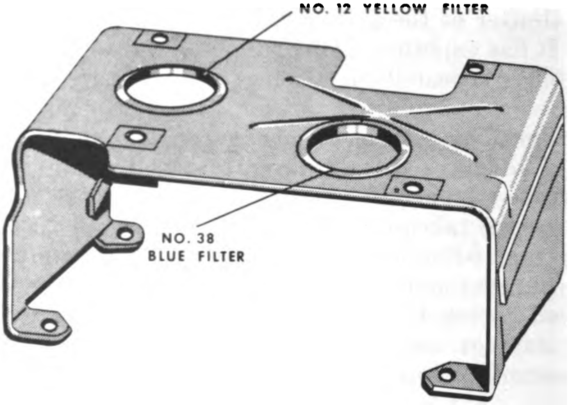


Figure 10–16.—Type M1G–2 gunsight camera mount.

Two filters are provided for use with the CG–4 gunsight camera. One is a No. 38 blue filter, and the other is a No. 12 yellow filter. Two threaded holes are provided in the mount (see (1) and (3), fig. 10–16) to accommodate these filters. The filter being used with the camera is screwed into the hole directly over the light path from the reflector plate to the prism. The other filter is screwed into the spare storage hole.

Installation.—As a general rule, all aircraft having automatic computing gunsights also have mounts and electric power cables provided for the CG–4 gunsight cameras. Position the CG–4 gunsight camera on the M1G–2 mount and secure it there. Installation of the camera and mount of the Mk 18 computing gunsight is made by removing the reflector hood and mounting the unit on the lens bracket assembly with four fillister-head screws. The electrical power cable is then connected to complete the installation.

Caution: Before connecting the power supply cable, check the polarity of the voltage at pin "C." It should read a positive polarity of 24 to 27.5 volts. If the polarity is reversed, the motor will run backwards and no pictures will be taken.

Installation of the CG–4 gunsight camera and the M1G–2 mount on the Mk 23 computing sight is the same as for the Mk 18 sight except that four ⅜-inch spacers are needed to raise the mount for proper clearance of the mount from the reflector glass on the Mk 23 gunsight. On certain other installations, it may be necessary to rotate the gunsight camera 180 degrees on special mounts.

OPERATION.—Pictures taken by the CG–4 gunsight camera are obtained by photographing the reticle of the computing sight directly over the reflected image of the target and giving proper orientation of the combined image to the picture area. The camera will operate automatically during the ranging and firing cycle of the guns. A witness mark, which is solenoid operated by a remote switch in the gunfiring circuit, appears in all pictures taken during the ranging. However, these marks disappear in those pictures taken during the time the trigger control switch is depressed.

NOTE: The CG–1, CG–2, and CG–3 GUN CAMERAS correspond in design and appearance to certain of the AN type gun cameras. However, the CG–4 is a GUNSIGHT CAMERA for taking still pictures of the reflected images of the aiming reticle and the target on the Mk 18 and Mk 23 computing gunsights.

Film loads for the magazine of the CG–4 camera should be 20-foot lengths of double perforated 16-mm film of speed group 50. It must be wound on the magazine supply spool EMULSION SIDE OUT.

The shutter speeds are set on the CG–4 camera by the shutter speed control, (13) of figure 10–15, on the camera body. To change speeds, depress the dial and move it to the desired position.

The diaphragm stops are set by the diaphragm control dial, (11) of figure 10–15, on the camera body. The lens opening (or stop) being used is indicated in the lens opening window on the body of the camera.

The film footage indicator on the indicator reset control, (15) of figure 10–15, shows the number of feet of film exposed. This dial should be set to correspond with the amount of film in the magazine at the time of inserting the magazine. It may be set at any time without damage to the camera or film.

The No. 38 blue filter is used at all times when the target aircraft is painted blue. The No. 12 yellow filter is for use when the target is yellow or silver in color.

The film magazine should be firmly inserted with the fingertips, bearing to the right to make sure that it seats properly against the shutter opening.

No attempt should be made by other than qualified personnel to repair, adjust, or overhaul the CG–4 gunsight camera. If found to have faulty mechanisms or wiring troubles, it should be removed from the aircraft and returned to the authorized overhaul activity.

Gun Cameras Type N–6 and AN–N–6

These two gun cameras are practically identical to the AN–N–4. They are both Fairchild cameras. (See fig. 10–17.) There are only a few minor differences in construction between these cameras. An apparent difference exists in the overrurn controls, and a few other minor details are noticeable. However, their operation and overall appearance are essentially the same.

In figure 10–17 it will be noted that an erector has been fitted to the lens assembly of the type N–6 gun camera. The erector assembly (fig. 10–18) consists of a 90-degree prism assembly contained within a prism housing (1), a glass dust

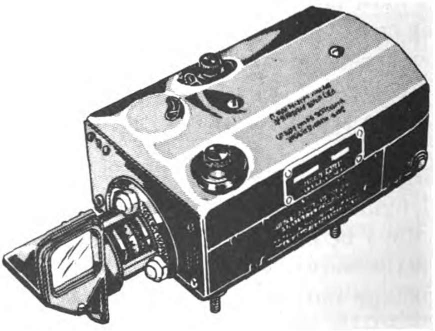


Figure 10–17.—Type N–6 gun camera with erector mounted.

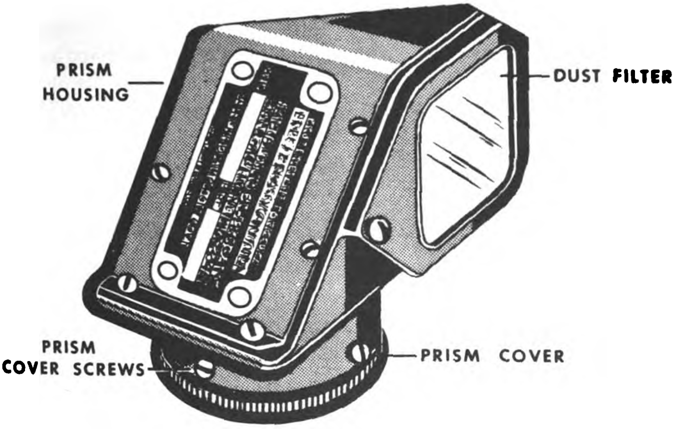


Figure 10–18.—Components of the gun camera erector.

filter (2), and a prism cover (3). Items (2) and (3) are removable. The erector is attached to the lens by removing the prism cover and securing the erector to the lens housing with the four prism cover screws.

The erector is installed on the gun camera when it is desired (or necessary) for the camera to be mounted in the cockpit of the aircraft. In such installations, the gun camera is mounted forward of the gunsight on the coaming above the instrument panel. It is placed on a bracket which is fastened to the coaming, with the mounting lugs down. However, the bracket and camera are rotated 90 degrees from the longitudinal (lengthwise) axis of the aircraft. In this position, the camera faces athwartships, and the erector dust filter, (2) of figure 10–18, faces forward. In this position the installation is least likely to obstruct the forward vision of the pilot, makes loading and unloading easier, and it will not interfere with the operation of the gunsight.

Provisions have been made in order that the gun camera erector may be mounted on all gun cameras which have complete 35-mm, f3.5 plain lens assemblies. This, of course, includes all the AN type gun cameras.

A detailed discussion of the N–6 and AN–N–6 gun cameras will not be given in this chapter. The reason for this is that the greater majority of the combatant aircraft currently in use are provided with the AN–N–6A type gun camera.

QUIZ

1. The filter for use under normal light conditions with black and white film is the
   a. minus clear
   b. optical clear
   c. minus blue
   d. Kodachrome haze

2. All AN type cameras use
   a. 8-mm film
   b. 16-mm film
   c. 35-mm film
   d. 20-mm film

3. The film footage indicator on the AN type and Mk 8 Mod 0 gun cameras indicates the
   a. amount of film in the camera
   b. amount of film exposed
   c. amount of unexposed film in camera
   d. amount of film that can be loaded

4. The speed change dial controls the number of frames per second by changing the
   a. diaphragm opening
   b. gear ratio of gear train
   c. speed of drive motor
   d. takeup gear

5. When changing the shutter speed of the camera make certain that the
   a. gear motion has stopped
   b. film magazine is removed
   c. takeup gear clutch is disconnected
   d. power lead is disconnected

6. The AN type or Mk 8 Mod 0 camera motor is protected from overloading by
   a. overrun controls
   b. built in governors
   c. heat switch
   d. extra field winding

7. The AN type and Mk 8 Mod 0 cameras are boresighted by use of the
   a. Mk 1 Mod 1 boresight
   b. Mk 1 boresight
   c. AN–M1 boresight
   d. AN–1 boresight

8. When using Kodachrome film under other than normal conditions, use the
   a. minus blue filter
   b. optical clear filter
   c. type A correction filter
   d. Kodachrome haze filter

9. All AN type cameras are equipped with a heating element for low temperatures to
   a. prevent film from becoming brittle due to cold
   b. heat the motor
   c. prevent sluggish operation
   d. keep lenses clear

10. The film magazine used in all types of AN cameras is the
   a. AN–M6
   b. AN–6
   c. AN–6A
   d. AN–A–6

11. The purpose of the overrun control in AN type cameras is to
   a. take up any slack in the film
   b. record results after the firing switch is released
   c. control speed of drive motor
   d. stop camera when all film is exposed

12. The overrun control may be set to vary overrun time in increments of 1 second up to
   a. 4 seconds
   b. 3 seconds
   c. 5 seconds
   d. 7 seconds

13. The film footage indicator on the CG–4 gunsight camera shows
   a. amount of film loaded
   b. amount of unexposed film
   c. amount of film exposed
   d. speed of film exposure

14. The film magazine AN–A–6 holds a maximum of
   a. 20 feet of film
   b. 40 feet of film
   c. 50 feet of film
   d. 60 feet of film

15. Before inserting the AN–1 boresight the shutter of the gun camera should be
   a. open
   b. closed
   c. removed
   d. none of the above

16. In most instances the AN type gun camera, when used in fighter type aircraft is mounted in the
    a. cockpit
    b. wing
    c. nose section
    d. none of the above

17. Incorrect connection of power cable and camera receptacle will cause the guns to
    a. fire automatically
    b. not fire
    c. fire singly
    d. none of the above

18. The CG–4 gunsight camera is a still picture camera operated
    a. manually
    b. electrically
    c. automatically
    d. none of the above

19. The shutter of the CG–4 gunsight camera has exposure settings of
    a. $\frac{1}{100}$ and $\frac{1}{200}$ seconds
    b. $\frac{2}{100}$ and $\frac{2}{200}$ seconds
    c. $\frac{3}{100}$ and $\frac{3}{200}$ seconds
    d. $\frac{6}{100}$ and $\frac{6}{200}$ seconds

20. The electric motor on the CG–4 gunsight camera is designed to operate on
    a. 6 volts d. c.
    b. 12 volts d. c.
    c. 27.5 volts d. c.
    d. 110 volts d. c.

21. The CG–4 gunsight camera uses the
    a. MG–1A magazine
    b. MG–1 magazine
    c. AN–6A magazine
    d. AN–A–6 magazine

22. Before connecting the power supply cable, check the polarity of the voltage at pin "C." It should read
    a. positive polarity
    b. negative polarity
    c. reverse polarity
    d. none of the above

23. Pictures taken by the CG–4 gunsight camera are obtained by photographing
    a. fixed cross of the computing gunsight
    b. gyro reticle of the computing gunsight
    c. gyro reticle over the target image
    d. fixed cross over the target reflection

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

SMALL ARMS

1. b.
2. d.
3. b.
4. c.
5. d.
6. c.
7. c.
8. a.
9. b.
10. d.
11. a.
12. a.
13. b.
14. d.
15. b.
16. c.
17. d.
18. a.
19. b.
20. a.
21. a.
22. c.
23. d.
24. c.
25. d.

CHAPTER 2

MACHINE GUN CALIBER .50 M2

1. c.
2. d.
3. b.
4. a.
5. a.
6. a.
7. c.
8. a.
9. d.
10. c.
11. d.
12. a.
13. a.
14. c.
15. d.
16. b.
17. d.
18. a.
19. b.
20. c.
21. a.
22. d.
23. b.
24. b.
25. a.
26. a.
27. b.
28. d
29. d.
30. a.
31. b.
32. d.
33. c.
34. c.
35. a.
36. c.
37. a.
38. c.
39. a.
40. c.

CHAPTER 3

20-MM AIRCRAFT GUNS

1. d.
2. a.
3. c.
4. c.
5. b.
6. a.
7. b.
8. a.
9. c.
10. c.
11. d.
12. a.
13. d.
14. c.
15. b.
16. a.
17. d.
18. a.
19. b.
20. c.
21. d.
22. b.
23. a.

CHAPTER 4

ELECTRIC TURRETS

1. a.
2. d.
3. d.
4. b.
5. c.
6. d.
7. d.
8. a.
9. d.
10. b.
11. a.
12. b.
13. a.
14. c.
15. b.
16. b.
17. d.
18. d.
19. d.
20. d.
21. a.
22. b.
23. c.
24. b.
25. c.
26. b.
27. a.
28. d.
29. c.
30. a.
31. c.
32. c.
33. b.

CHAPTER 5

ELECTROHYDRAULIC TURRETS

1. b.
2. a.
3. a.
4. c.
5. d.
6. b.
7. b.
8. d.
9. c.
10. d.
11. c.
12. c
13. b.
14. b.
15. d.
16. b.
17. c.
18. d.
19. c.
20. d.
21. c.
22. b.
23. c.
24. a.

CHAPTER 6

ILLUMINATED AND COMPUTING GUNSIGHTS

1. d.
2. a.
3. a.
4. b.
5. b.
6. a.
7. c.
8. d.
9. c.
10. c.
11. b.
12. b.
13. b.
14. a.
15. a.
16. b.
17. c.
18. a.
19. d.
20. b.
21. c.
22. d.
23. d.
24. d.
25. d.

CHAPTER 7

BOMBSIGHTS

1. a.
2. b.
3. c.
4. a.
5. d.
6. d.
7. d.
8. a.
9. b.
10. c.
11. c.
12. d.
13. d.
14. d.
15. b.

16. d.
17. a.
18. b.
19. b.
20. c.
21. d.
22. c.
23. c.
24. d.
25. b.
26. c.
27. a.
28. a.
29. c.
30. b.
31. d.
32. d.
33. c.
34. b.
35. c.

CHAPTER 8

TOW TARGETS

1. c.
2. a.
3. c.
4. a.
5. d.
6. b.
7. d.
8. c.
9. d.
10. b.
11. a.
12. c.
13. b.
14. d.
15. d.
16. b.
17. b.
18. d.
19. b.
20. d.
21. a.
22. c.
23. d.

CHAPTER 9

SUSPENSION AND RELEASING EQUIPMENT

1. d.
2. b.
3. c.
4. a.
5. b.
6. c.
7. c.
8. c.
9. b.
10. b.
11. c.
12. c.
13. d.
14. c.
15. d.
16. b.
17. b.
18. a.
19. c.
20. a.
21. c.
22. b.
23. d.

CHAPTER 10

GUN CAMERAS

1. c.
2. b.
3. c.
4. b.
5. a.
6. c.
7. d.
8. d.
9. c.
10. d.
11. b.
12. c.
13. c.
14. c.
15. a.
16. b.
17. a.
18. b.
19. a.
20. c.
21. b.
22. a.
23. c.

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APPENDIX II

QUALIFICATIONS FOR ADVANCEMENT IN RATING

AVIATION ORDNANCEMAN (AO)

RATING CODE NO. 6500

General Service Rating

Scope

Aviation Ordnancemen maintain, service, remove, repair, install, operate, and handle small arms and aviation ordnance equipment including aircraft guns, turrets, powered gun mounts, rocket launchers, suspension and release mechanisms, and pyrotechnic, tow-target, and munitions handling equipment; operate and perform routine servicing and checking of aviation gun, bomb, and rocket sights and aviation fire control equipment including that which is electronically controlled; stow, maintain, service, handle, install, and remove aviation munitions and pyrotechnics; maintain and operate a small arms range.

Emergency Service Rating

AVIATION ORDNANCEMEN U (Utility), Rating Code No. 6501------AOU

Maintain, service, remove, repair, install, operate, and handle small arms and aviation ordnance equipment including aircraft guns, rocket launchers, and suspension and release mechanisms, pyrotechnic, tow-target, and munitions handling equipment; operate and perform routine servicing and checking of aviation gun, bomb and rocket sights; stow, maintain, service, handle, install, and remove aviation munitions and pyrotechnics; maintain and operate a small arms range.

AVIATION ORDNANCEMEN T (Turrets), Rating Code No. 6502------AOT

Maintain, service, remove, repair, install, and operate aircraft turrets and powered gun mounts.

Navy Job Classifications and Codes

For specific Navy job classifications included within this rating and the applicable job codes, see Manual of Enlisted Navy Job Classifications, NAVPERS 15105 (Revised), Codes AO–6800 to AO–6899.

Qualifications for Advancement in Rating

Qualifications for advancement in rating	*Applicable rates*		
	AO	AOU	AOT
100 PRACTICAL FACTORS			
101 OPERATIONAL			
1. Preserve, depreserve, adjust, and install guns	3	3	3
2. Operate aviation munitions handling equipment	3	3	3
3. Assemble, adjust, and install aviation ordnance fuzes, pyrotechnics, and munitions normally used in own activity	3	3	----
4. Stow, handle, and load aviation munitions, pyrotechnics, and aircraft-laid mines, observing local and general safety precautions	3	3	3
5. Install, remove, and perform preflight operational checks to gun cameras and their magazines in accordance with local instructions	3	3	3
6. Belt and calibrate aircraft gun ammunition	3	3	----
7. Install, remove, adjust, and operate tow-target equipment	2	2	----
8. Operate electronic fire control equipment to determine proper functioning of ordnance or armament components	2	----	----
9. Perform stray-voltage and circuit continuity safety check on aircraft armament circuits in accordance with current instructions	2	2	----
102 MAINTENANCE AND/OR REPAIR			
1. Demonstrate safe and proper use and maintenance of measuring instruments and hand and power tools used for aviation ordnance installation, maintenance, and repair	3	3	3
2. Use working drawings, blueprints, and wiring diagrams in servicing, repairing, assembling, and installing aviation ordnance equipment	3	3	3
3. Select and demonstrate safe and proper use of all instruments furnished as general test equipment in own unit	3	3	3
4. Inspect, clean, lubricate, preserve, adjust, and replace minor parts of aircraft sights	3	3	3
5. Inspect, clean, lubricate, adjust, and preserve aircraft turrets	3	----	3

	Qualifications for advancement in rating	*Applicable rates*		
		AO	AOU	AOT
102	MAINTENANCE AND/OR REPAIR—Continued			
	6. Inspect, clean, service, lubricate, adjust, preserve, depreserve, and perform authorized repairs to small arms, and aircraft guns	**3**	3	----
	7. Inspect, clean, lubricate, preserve, and perform authorized parts replacement, tests, and adjustments to aviation ordnance handling equipment, except automotive equipment	**3**	3	----
	8. Boresight and align aircraft sights, guns, and gun cameras	**2**	2	2
	9. Check, adjust, and/or align aircraft bomb and rocket suspension and release equipment	**2**	2	----
	10. Inspect, clean, lubricate aviation electronic fire control equipment	**2**	----	----
	11. Demonstrate safe and proper use of specialized ordnance test equipment	**2**	2	2
	12. Replace unserviceable parts, assemblies, or subassemblies; align, test, and make required adjustments to aircraft turrets	**1**	----	2
	13. Adjust, preserve, and make minor parts replacements not requiring realignment to aviation electronic fire control equipment	**1**	----	----
	14. Prepare charts and design templates for use in boresighting aircraft armament	**1**	1	1
	15. Maintain and service aircraft gun ammunition linking and delinking equipment	**C**	C	----
103	ADMINISTRATIVE AND/OR CLERICAL			
	1. Maintain required inventory and performance records of aviation armament and ordnance equipment, munitions and pyrotechnics	**3**	3	3
	2. Use applicable publications and instructions for the handling, stowage, issue, maintenance, and operation of aviation ordnance and armament equipment, munitions, and pyrotechnics	**3**	3	3
	3. Instruct in safety regulations and precautions pertaining to small arms and aviation ordnance	**2**	2	2

	Qualifications for advancement in rating	*Applicable rates*		
		AO	AOU	AOT
103	ADMINISTRATIVE AND/OR CLERICAL			
	4. Train and supervise personnel engaged in maintenance and repair of:			
	a. Aircraft armament and aviation ordnance equipment; excluding fire control equipment	1	1	----
	b. Aircraft turrets	1	----	1
	5. Train and supervise personnel in proper handling of aviation munitions and pyrotechnics	1	1	----
	6. Train and supervise personnel engaged in maintenance of aviation fire control equipment	C	----	----
	7. Organize and administer facilities for maintenance and repair of aviation ordnance and armament equipment	C	C	C
	8. Supervise the use, filing, and maintenance of publications, logs, and records and preparation of reports required by own activity	C	C	C
	9. Determine allowances; requisition, supervise inventory of, and account for allowed materials in accordance with current directives	C	C	C
	10. Organize, instruct in, and conduct small arms firing practice	C	C	----
200	EXAMINATION SUBJECTS			
201	OPERATIONAL			
	1. Safety precautions for handling and stowing aviation munitions, pyrotechnics, and aircraft-laid mines	3	3	3
	2. Safety precautions to be observed in the use of aviation munitions, pyrotechnics, and ordnance equipment	3	3	----
	3. Types, nomenclature of parts, and assemblies of:			
	a. Small arms and aircraft guns	3	3	3
	b. Aircraft turrets	3	----	3
	c. Aircraft sights	3	3	3
	d. Aviation electronic fire control equipment	3	----	----
	e. Fuzes	3	3	----
	4. Types, operation, and components of aviation ammunition, bombs, rockets, fuzes, pyrotechnics, and JATO	3	3	----

Qualifications for advancement in rating	Applicable rates		
	AO	AOU	AOT
201 OPERATIONAL			
5. Procedures, sources of information, and safety precautions for belting and calibrating aircraft gun ammunition	3	3	----
6. Operating principles and functions of those components common to all aircraft equipment in each of the following groups:			
a. Aircraft noncomputing sights	3	3	3
b. Aircraft computing sights	2	----	2
c. Bomb sights	2	----	----
d. Bomb directors	1	----	----
7. Operating characteristics of electrical and hydraulic aircraft turrets	2	----	3
202 MAINTENANCE AND/OR REPAIR			
1. Proper use of measuring instruments and of hand and power tools common to rating	3	3	3
2. Identify standard symbols found in electrical wiring diagrams of aviation ordnance equipment	3	3	3
3. Tests requiring use of simple ohmmeter, ammeter, and voltmeter	3	3	3
4. Determine values of voltage, current, and resistance in series and parallel resistor combinations	3	3	3
5. Cleaning solutions, lubricants, and preservatives used in maintenance of aviation ordnance and armament equipment	3	3	3
6. Procedures for determining and correcting malfunctions of aircraft guns	3	3	2
7. Solve problems in:			
a. Square and cubic areas for storage and pressures	3	3	3
b. Ratio and proportion for hydraulics, pneumatics, and electricity	3	3	3
c. Graph reading for ballistics and boresighting	2	2	2
d. Substitution of known values in formula	2	2	2
8. Procedures for adjusting and maintaining:			
a. Aircraft noncomputing sights	3	3	3
b. Aircraft computing sights	2	----	----
c. Bomb sights	2	----	----

Qualifications for advancement in rating	*Applicable rates*		
	AO	AOU	AOT
202 MAINTENANCE AND/OR REPAIR			
9. Procedures, sources of information, and safety regulations for boresighting aircraft sights, guns, and gun cameras	2	2	2
10. Procedures for localizing a defective component part in a circuit by means of measurement of voltage, resistance, and current	2	2	2
11. Procedures for adjustment and maintenance of aircraft bomb and rocket suspension and release equipment	2	2	----
12. Procedures for adjustment and maintenance of aircraft turrets and powered gun mounts	2	----	3
13. Procedures and sources of information relative to the preparation of boresighting charts and templates	1	1	1
14. Identification of standard electronic parts symbols used in schematic drawings	1	----	----
15. Procedures for adjusting and maintaining bomb directors	1	----	----
16. Practical applications of the principles of internal and external ballistics to aviation ordnance	C	C	C
203 ADMINISTRATIVE AND/OR CLERICAL			
1. Purposes and types of entries made in maintenance and inventory records kept for aviation ordnance and armament equipment, aviation munitions, and pyrotechnics	3	3	3
2. Safety regulations and precautions pertaining to small arms and aviation ordnance and armament equipment	2	2	2
3. Types of information found in each of the following publications: OP, OD, OCL, OHI, OML, ORDALTS, NavAer Publications Index, Aircraft Armament Changes, and Aircraft Armament Bulletins	2	2	2
4. Use of applicable allowance lists, OP's, parts catalogs, and forms in the requisitioning, salvage, and survey of aviation ordnance materials	C	C	C
5. Procedures and regulations for conducting small arms firing practice	C	C	----

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